# POWER PLANT ENGINEERING

Trade-Mark, Reg. U. S. Pat. Office

VOL. XXV CHICAGO, DECEMBER 1, 1921 No. 23


## Steam for Battle Creek Sanitarium

OUTSTANDING FEATURES OF THIS PLANT ARE: MECHANICAL COAL AND ASH HANDLING, AUTOMATICALLY CONTROLLED UNDERFEED STOKERS, SPECIAL WATER TREATMENT AND A GRAPHIC RECORD SYSTEM

SERVICES RENDERED at the Battle Creek Sanitarium, of Battle Creek, Mich., have made this institution famous throughout the entire country and a large share of these services depend directly upon the proper functioning of the power plant. Thus we can readily appreciate why, when the demands upon former equipment overtaxed the capacity of the plant, the management of the institution decided to build a plant that would have ample capacity for some time to come and to provide the plant with equipment having unfailing reliability.

This institution expects from its boiler and engine houses, steam for operating the electric generators, heating main buildings and cottages, greenhouses, water for baths and swimming tanks, cooking, laundering, sterilizing, ice making and refrigerating. Electricity generated in the engine house is used for lighting, pumping, running fans and other small motors, elevators, X-ray machines and other medical purposes. Compressed air is also furnished by the power plant for cleaning, operating elevator doors and hoists, bubble baths, surgical work and for numerous other purposes. Water, both hot and cold, for all uses is served to the institution by the power plant. Thus it may readily be

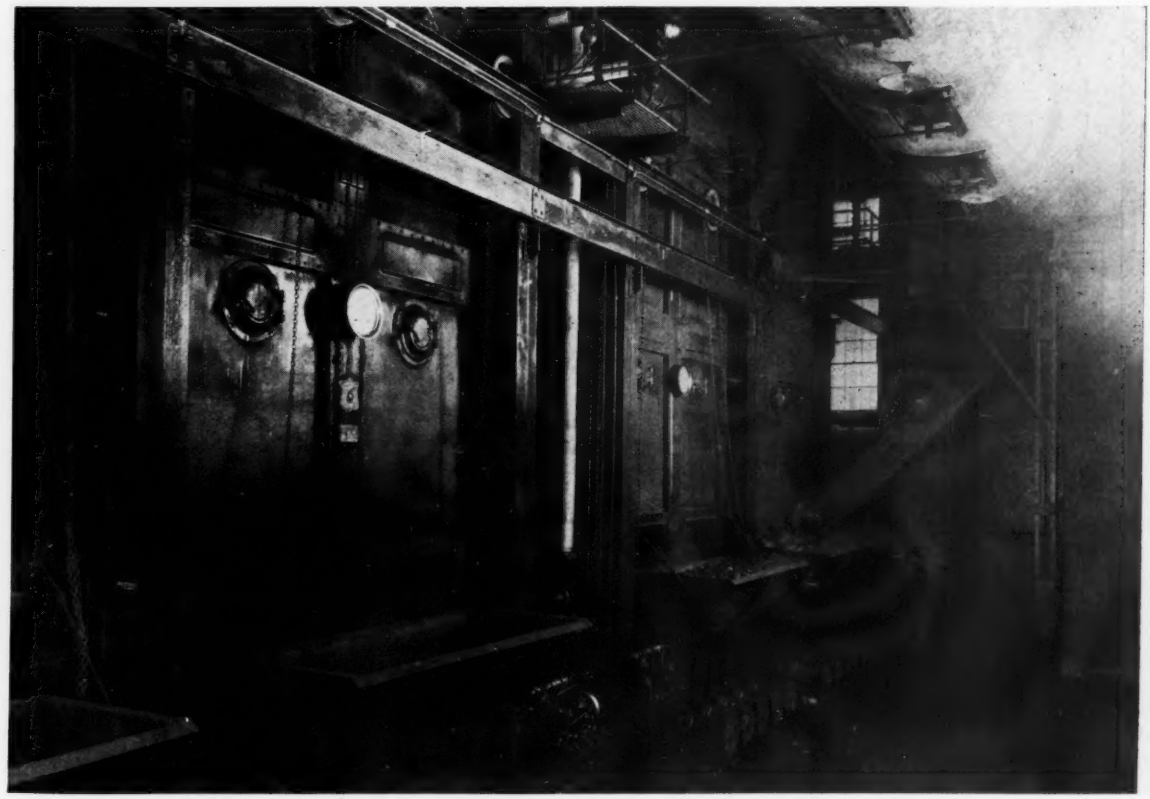


FIG. 1. VIEW OF BOILER ROOM OF BATTLE CREEK SANITARIUM

appreciated what an important part the power plant plays in the Battle Creek Sanitarium which consists of eight large buildings and 30 cottages, covering an area of 43 acres, all receiving service from the centrally located plant.

Ultimate plans call for an entirely new electric generating plant separated from the boiler house by a party wall, but at the present time the new part of the plant consists only of the boiler house and equipment. Here are installed four 500-hp. Stirling, type 0-20 boilers all on one side of the firing aisle with space provided on the other side of the aisle for an equal number of boilers of the same size. While built for 150 lb. working steam pressure the engines now operating will withstand only 115 lb. pressure, so until new generating units are installed the boilers will be operated at the lower pressure. These boilers are arranged two in a setting, the furnaces being separated by a division wall and lined with McLeod & Henry refractory.

On each boiler are four 3-in. Crane pop safety valves. These are mounted on Y fittings, the discharge being through short pipes to the upper part of the boiler house.

### Coal Handling

Ordinarily coal is delivered daily to the boiler plant in motor trucks, but for storage purposes a sidehill pit with concrete walls on two sides, the boiler house wall on the other and a concrete floor with a capacity of 10,000 T., has been provided. From the storage pit the coal is loaded into trucks by a mechanical loader and hauled upon the driveway where it is dumped into a hopper serving an apron feeder. The location of this hopper may be seen in Fig. 4 under the small pile of coal on the reinforced concrete driveway.

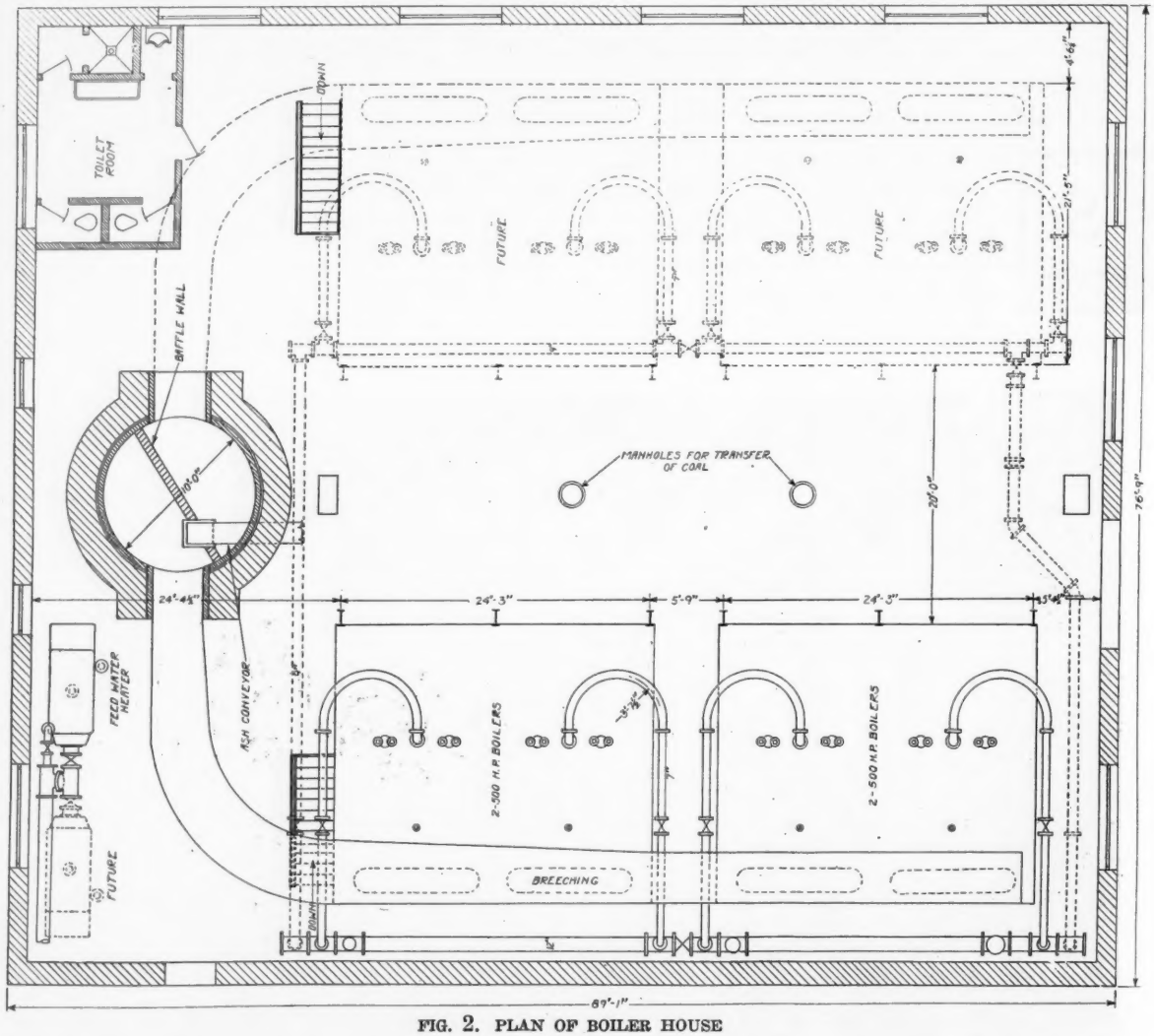



FIG. 2. PLAN OF BOILER HOUSE

The feeder delivers the coal to the hopper of a two-roll crusher where it is crushed, if need be, to a proper size for use in the stokers, or if of a usable size the rolls are spread apart and the coal goes directly to the bucket elevator and conveyor which delivers to a reinforced concrete bunker of 400 T. capacity directly over the firing aisle. Equally spaced along the bottom of the bunker are eight coal gates, operated by chain from the floor, which discharge to a traveling weight larry with a chute leading to the stoker hoppers.

Ashes discharge from the ashpits through chutes and holes in the basement floor fitted with iron gratings

to prevent oversize clinkers from passing to the bucket elevator and conveyor which delivers the ash to space in the smokestack below the entrance of the breeching. From the bottom of this ash storage bin a chute discharges the refuse to trucks at the back of the boiler house.

To operate this conveying equipment, all of which is the product of the Link-Belt Co., a 3-hp. motor is required on the apron feeder, one of 15-hp. is installed to operate the crusher and a 10-hp. motor drives the bucket elevator and conveyor. The capacity of this equipment is 30 T. per hr.

### Stokers and Combustion Control

Smokeless combustion is a prerequisite of this boiler plant for the health and comfort of all in the immediate vicinity must be guarded with the utmost care. The design of the furnaces and the provision of equipment which would insure smokeless operation of the plant were made special features of the engineering work on this plant.

Serving the boilers are five retort Jones underfeed automatic clearing stokers which are automatically controlled to maintain a constant steam pressure by varying the rate of coal fed and correctly proportioning the air supply. This is accomplished by means of the Cole valve which has eight points of speed adjustment for actuating the steam driven rams that force the coal into the retorts and is controlled in unison with the

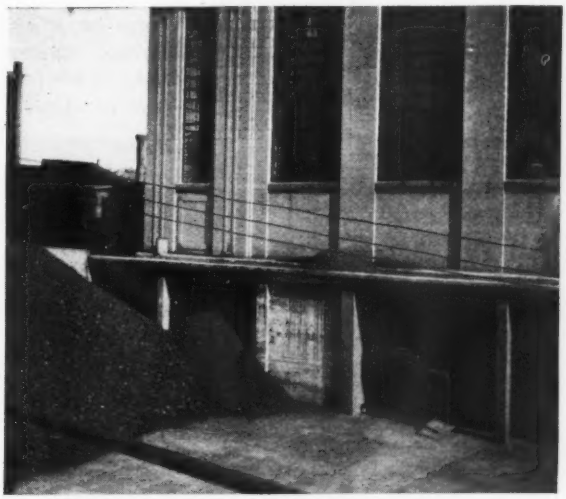


FIG. 4. COAL STORAGE PIT, UNLOADING DRIVEWAY AND BLOWOFF TANK FOR FUTURE BOILERS

speed of the fan that supplies the forced draft. Thus an increase in steam pressure causes the regulator to

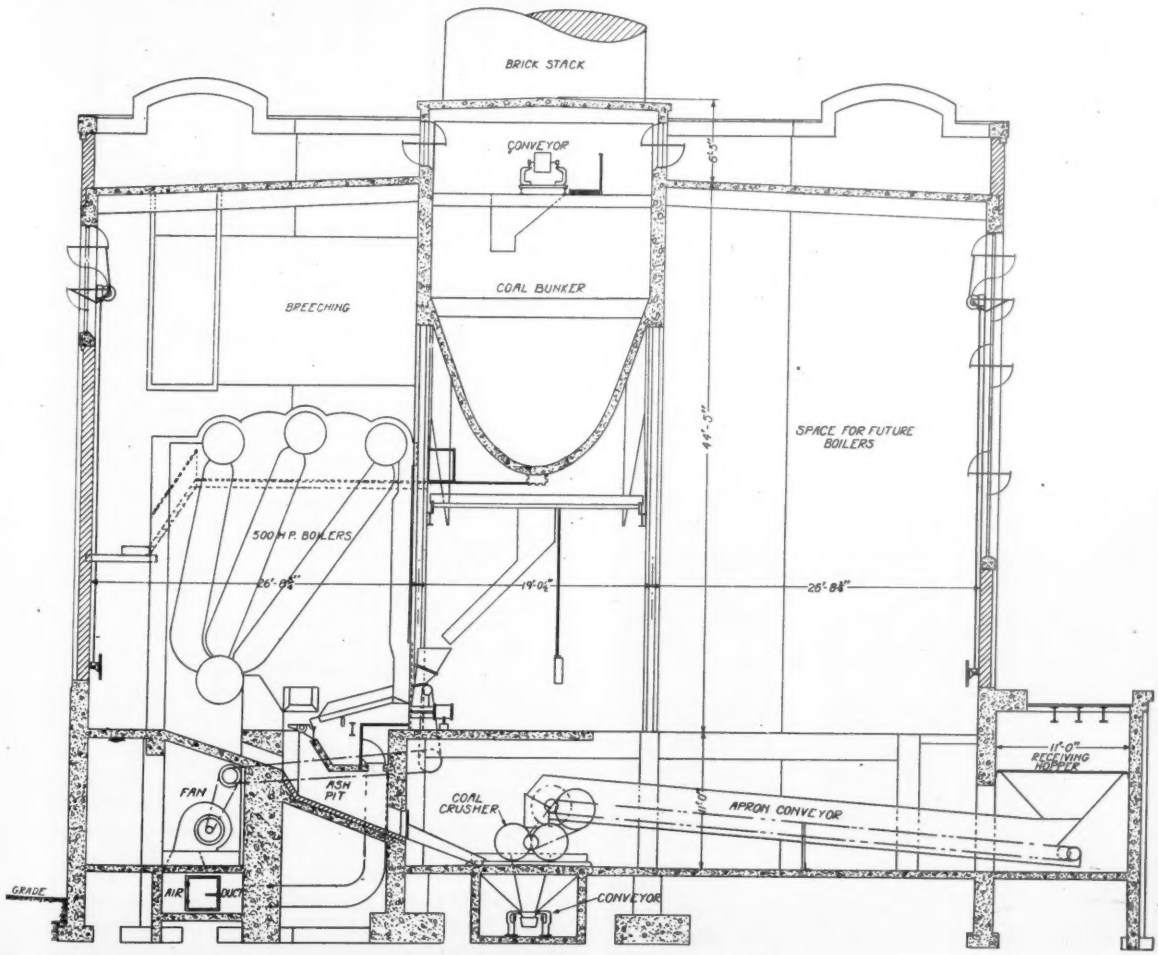



FIG. 3. CROSS-SECTION OF BOILER HOUSE

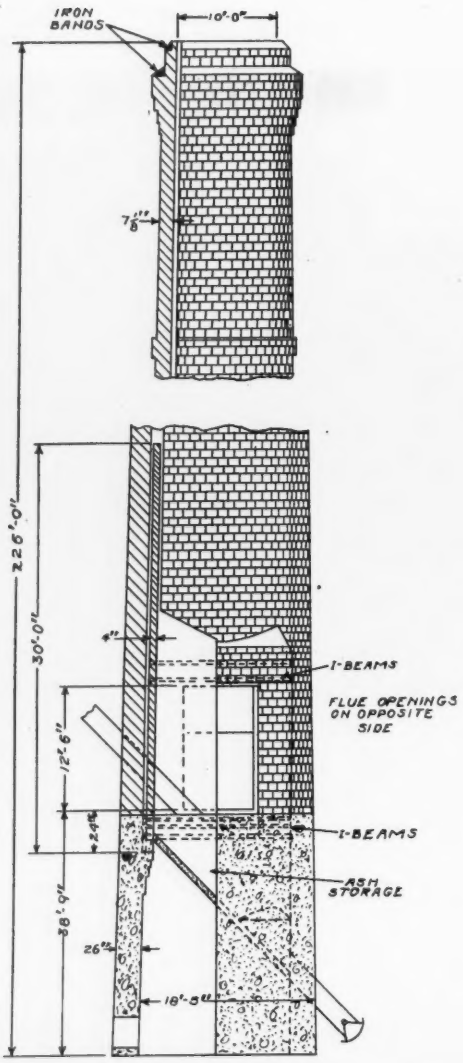



FIG. 5. PARTIAL CROSS-SECTION OF STACK SHOWING ASH STORAGE

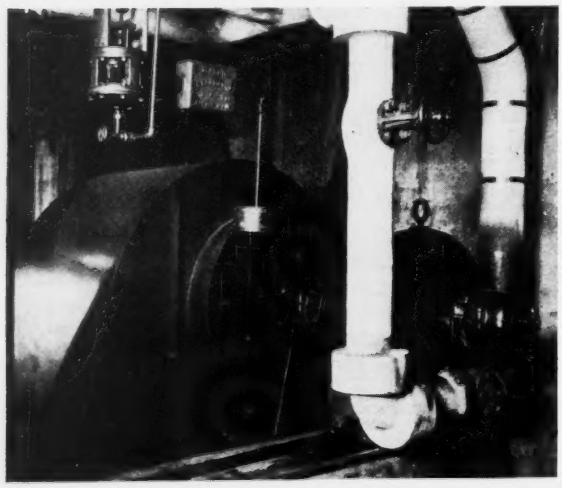


FIG. 6. FORCED DRAFT FAN UNIT

cut down the steam supply to the stoker rams and to the turbines driving the fans until correct steam pressure has been restored.

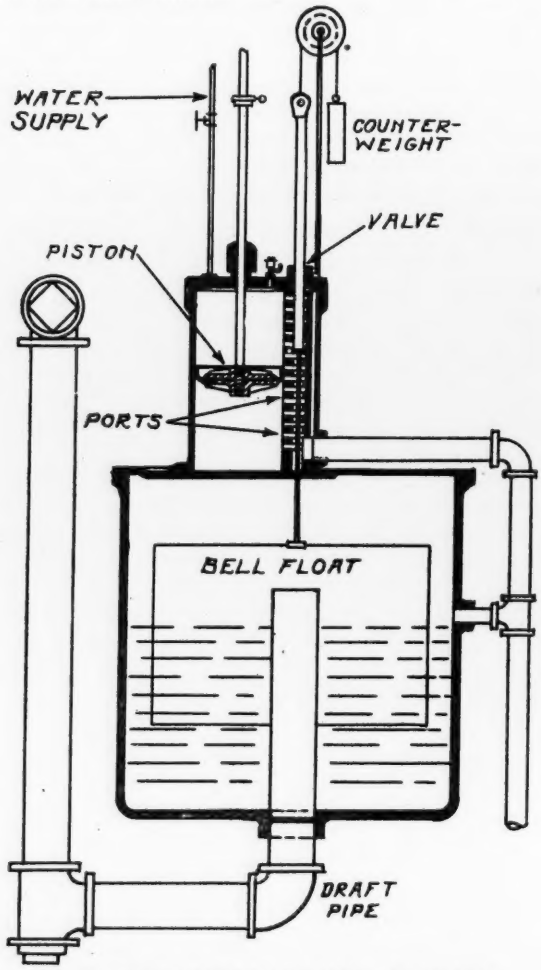



FIG. 7. CROSS-SECTION OF DAMPER REGULATOR

Forced draft to the tuyeres of the stoker is furnished by two fan units located in the basement and consisting of size No. 5 turbo conoidal fans made by the Buffalo Forge Co., direct connected to 45-hp. Terry steam tur-

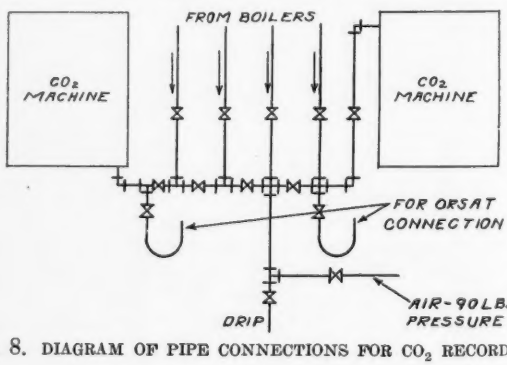



FIG. 8. DIAGRAM OF PIPE CONNECTIONS FOR $CO_2$ RECORDERS

bines which run normally at 1674 r.p.m.; but the speed of these turbines, as explained above, is increased as boiler pressure falls and reduced as the pressure increases from the desired operating pressure. This variation in speed is accomplished by means of a Mason regu-

lator placed in the steam supply line to the turbines. The air pressure in the wind box, as indicated by Schaeffer & Budenberg U-shaped draft gages mounted on each boiler setting, varies from 1 to 3 in. of water, depending, of course, upon the load being carried.

Draft over the fuel bed is controlled by a Craig damper regulator and varies from 0.05 to 0.1 in. of water, this being indicated by a Hays balanced draft gage which gives the readings for the furnace and also

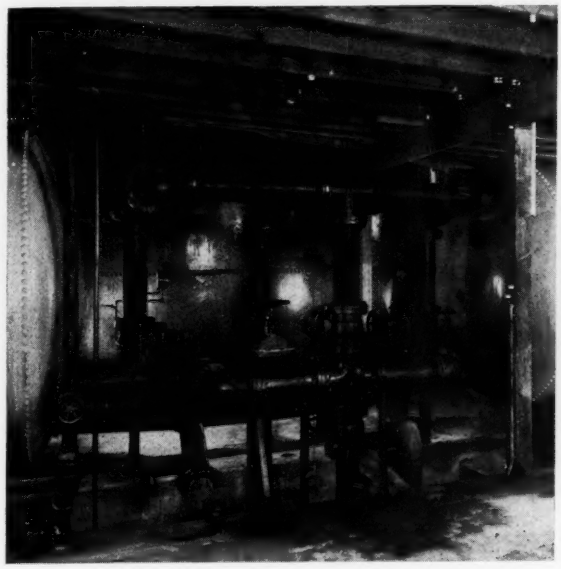


FIG. 9. PIPING FOR PRESSURE CLARIFIERS

the differential draft. A graphic record is also made of the furnace draft for the chief engineer's inspection.

The damper regulator is of a comparatively new design consisting of a bell float provided with a water seal within a cylindrical chamber. The underside of the bell communicates by a draft pipe to the boiler furnace. The top of the bell is attached to a piston control valve by a rod, the entire element being balanced by a coun-

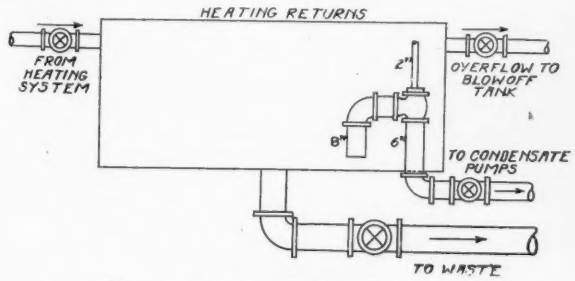



FIG. 10. PIPING OF HEATING RETURNS TANK

ter-weight which is varied to give desired draft conditions.

In a cylinder above the float chamber is a piston which operates the damper. The piston rod is attached to a cable which is connected to the damper arm and is so counterweighted as to have a tendency always to raise the piston and open the damper. This is resisted by a small water pressure over the piston supplied through a small pipe attached to the top of the cylinder. At the side of the cylinder is a series of ports which are opened or closed by the valve attached to the bell float. These ports allow the water from the upper part of the cylinder to run to waste, thus an increased draft lowers the bell float, drawing with it the valve and closing a port opening above the piston. As with this relation water cannot escape from above the piston, water pressure forces the piston down until one port above the piston is open for the escape of water. This motion is communicated to the damper, moving it slightly to-

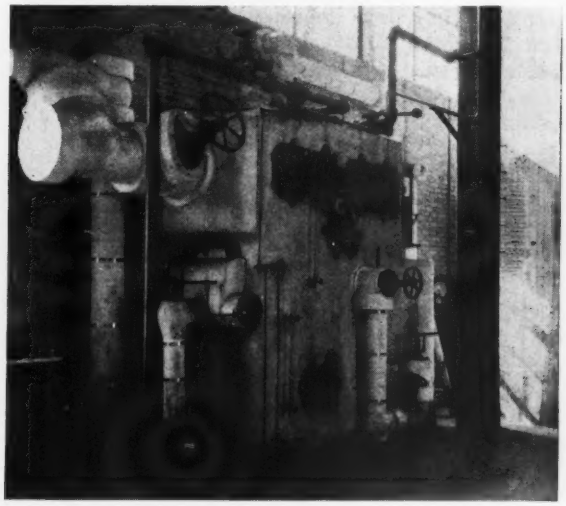


FIG. 11. METERING HEATER ON MAIN FLOOR OF BOILER HOUSE

wards the closed position, thus reducing the draft over the fire. The reverse takes place when the draft falls below that desired, only the opening of the damper takes place much quicker than the closing.

Each boiler is provided with a damper regulator so that draft is adjusted for each boiler individually and the load carried may be proportioned among the several boilers as desired. In the operation of the boilers, the

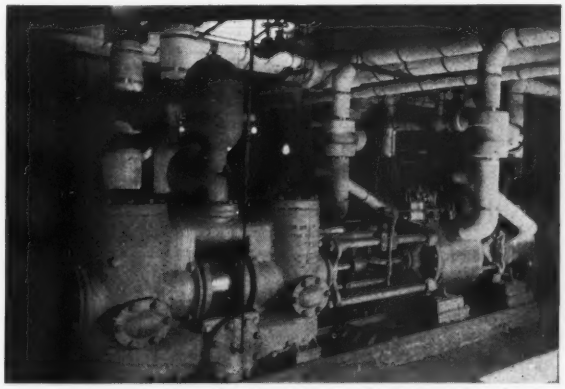


FIG. 12. FEED PUMPS IN BASEMENT OF BOILER HOUSE

differential draft and flue gas temperature are watched carefully and prevented from becoming excessive for the existing load conditions by dusting the tubes, for which purpose Diamond mechanical soot blowers are provided.

All four boilers now installed are served by one steel plate breeching 5 ft. wide and varying in height from 3 ft. at boiler No. 1 to 12 ft. at the stack. The stack, which was built by the Alphons Custodis Chimney Construction Co., stands 225 ft. above the boiler house

foundation or basement floor and is 10 ft. in diameter at the top, having been designed to serve the ultimate capacity of the plant. The first 38 ft. of the stack above the foundation is of reinforced concrete while the remainder is of radial brick.

For recording flue gas analyses, two $CO_2$ recorders are provided, one being a Republic, the other a Hays combined $CO_2$ and draft recorder. A diagram showing the method of connecting these up is shown in Fig. 8 where it will be noted that records can be made of the gases from any two boilers. A drip is provided to relieve the piping of all condensate, also connection for Orsat instruments to be used in checking up the recorders and an air connection for blowing out the flue gas piping.

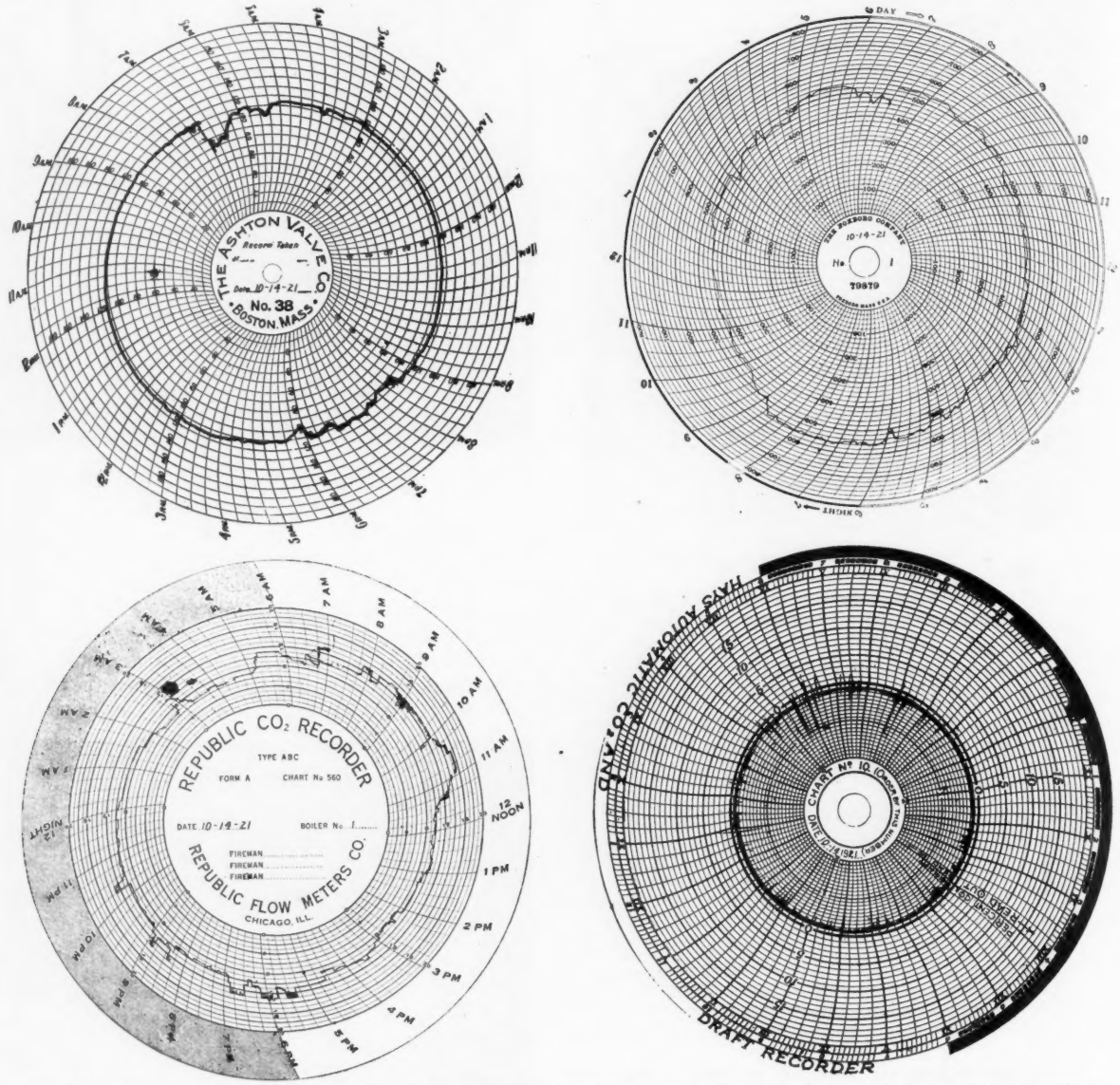



FIG. 13. GRAPHIC RECORDS OF STEAM PRESSURE, FLUE GAS TEMPERATURE, CARBONDIOXIDE AND WIND BOX PRESSURE

## WATER SUPPLY

ALL WATER used at the sanitarium comes from three 8-in. wells 125 ft. deep. The standing water level in these wells is about 7 ft. below the elevation of the pumps, but falls to 16 or 17 ft. running suction head. The pump house in which these wells are located is across the street from the boiler house and does not comprise a part of the new equipment except, however, that additional treating equipment has been installed here.

In the pump house are five motor-driven centrifugal pumps with a total capacity of 2100 g.p.m. which draw the water from the wells. This water, however, contains a great amount of scale forming impurities and it is all chemically treated before it leaves the pump house.

Delivery from the wells is directly to a continuous cold process lime and soda ash treating system. The demands on this equipment outgrew its capacity to such an extent that time was not given for proper precipitation, so that a Permutit system was added and the present practice is to treat all water with lime and soda

ash first, as was formerly the custom, then from the settling tank the water is pumped through Permutit pressure clarifiers or gravel filters, as they may be called, of which two are provided, to the Permutit softeners and out to the 105,000-gal. storage reservoir. The Permutit softeners, of which there are three units installed, have a total capacity of 400,000 gal. in 10 hr. when the hardness does not exceed 85 parts per million. These are regenerated with salt water every night.

Water used for boiler feed purposes is, of course, largely returns from the heating system but makeup water is drawn from the treated water supply system and delivered into the feed water heater as needed. The boiler water is, therefore, soft and gives no trouble from scale.

All heating returns come to a tank in the basement of the boiler house from which it flows by gravity to the receiver of a condensate pumping set consisting of a receiver and two Burnham simplex pumps, 6⅛ by 10 by 10 in. These pumps deliver under automatic float control to the Cochrane metering heater on the main floor of the boiler house.

An unusual system of piping is employed for the heating returns tank which prevents oil, that sometimes gets by the separators and into the return condensate, from going to the feed water heater. This is shown diagrammatically in Fig. 10. The heating returns enter at one end near the top with an overflow to the blowoff tank at the other. At the bottom is a pipe connection running to the sewer which is used for cleaning the tank. The connection to the condensate pumps is through a sort of gooseneck arrangement vented to the top of the tank to prevent siphoning of the oil which may be on the surface of the water. The entrance to this connection, it will be noted, is an 8-in. pipe which gives comparatively low velocity to the water and causes no disturbance of sediment that may have collected in the bottom of the tank.

When the level of the water reaches the bottom of the bend in the gooseneck, the suction to the pumps is broken by the 2-in. vent to the top of the tank and the reserve in the receiver at the pumps is drawn upon to feed the heater. The overflow from this tank goes to another of like dimensions similarly piped, but with the gooseneck higher in the tank. By this arrangement, only cold water goes to the sewer as the hot water rises to the top and has time to cool before going to discharge. This same tank will be used as a boiler blowoff tank for the future units and may be seen under the driveway in Fig. 4. A similar tank and piping is now installed at the back of the plant for taking care of the blowoff water from the present boiler installation.

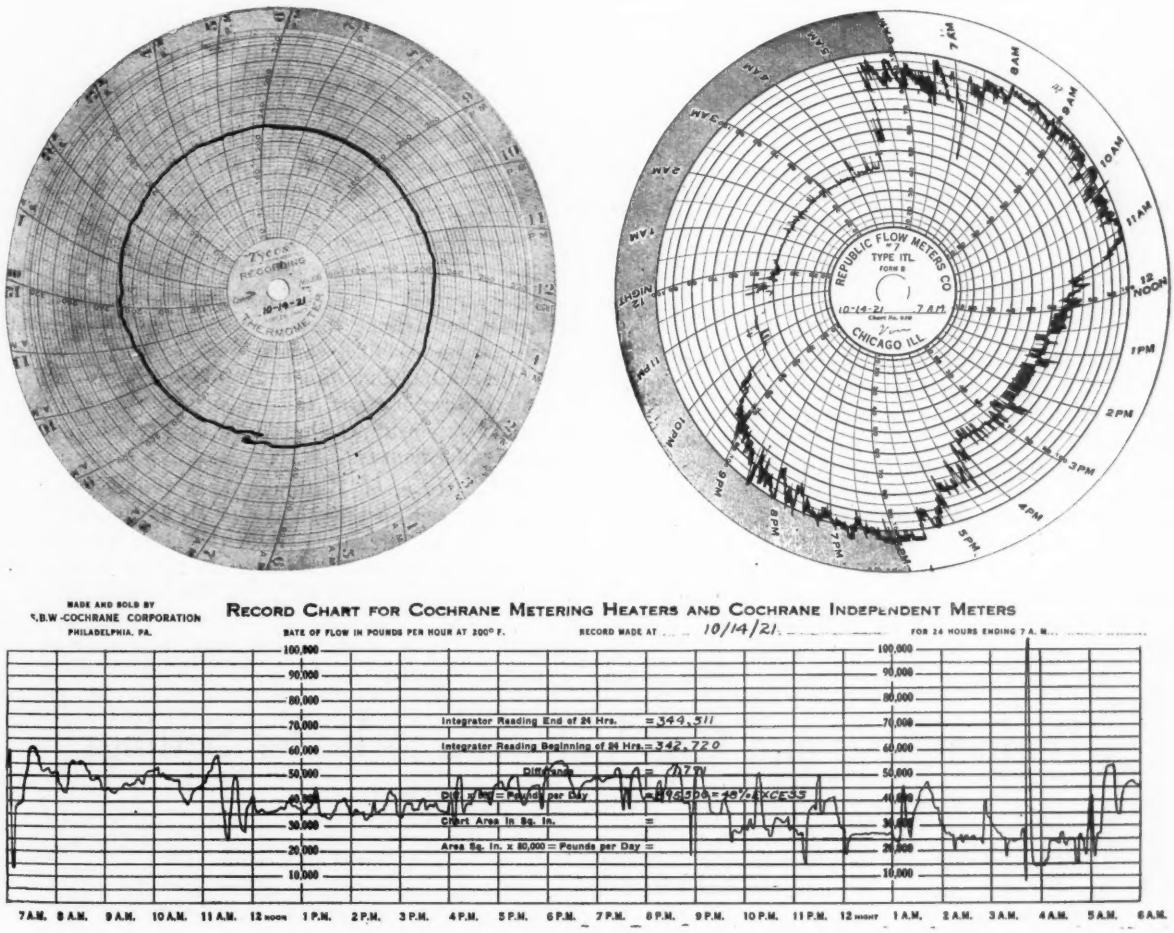

REPUBLIC FLOW METERS CO
TYPE ITL
CHICAGO ILL
MADE AND SOLD BY
C.B.W.-COCHRANE CORPORATION
PHILADELPHIA, PA.
RECORD CHART FOR COCHRANE METERING HEATERS AND COCHRANE INDEPENDENT METERS
RATE OF FLOW IN POUNDS PER HOUR AT 200° F.
RECORD MADE AT
10/14/21
FOR 24 HOURS ENDING 7 A. M.
Integrator Reading End of 24 Hrs. = 349,511
Integrator Reading Beginning of 24 Hrs. = 342,720
Difference
Chart Area in Sq. In.
Area Sq. In. x 80,000 = Pounds per Day =

FIG. 14. GRAPHIC RECORDS OF FEED WATER TEMPERATURE, STEAM FLOW AND FEED WATER FLOW

A special float operated valve arrangement is provided on the feed water heater which, when the water level begins to recede from its overflow point, first opens the steam throttle valve to the condensate pumps, then if there is not sufficient condensate being delivered, the float drops still farther and opens the makeup water valve which admits the treated water of the general system at a pressure reduced by a Boylston reducing valve from 60 to 20 lb. This water is carefully measured by an Enarc meter and found to be about 18 per cent of the total evaporation of the boilers.

Although the heater is of the open type, it takes steam from the exhaust steam heating system, which is fed by exhaust steam from all main and auxiliary steam driven machinery, and is subjected to a low pressure so that the temperature of the feed water as it leaves the heater is 210 to 215 deg. F. Only one heater is installed at the present time, but plans call for another of the same size and make when the other four boilers are installed. The rating of the heater is 100,000 lb. of water per hour.

To deliver the water from the heater to the boilers, two boiler feed pumps are installed in the basement. Both of these are Burnham, simplex, compound, plunger pumps with steam cylinders 12 and 18 in. in diameter, the plunger is 10 in. in diameter and the common stroke is 16 in.

The operation of these pumps is automatically controlled by a Copes pump governor which works in harmony with the Copes feed water regulators with which each boiler is provided. The water level in the boiler is not maintained constant with this type of regulator, but the feed is varied so as to store up heat in the water, during low load periods, which is flashed into steam during sudden increased demands for steam. The feed water connection at the boiler is into the rear drum through a check and angle valve and the water level in the boiler is indicated by a Reliance gage column with high and low water alarm attachments.

From the boilers, steam enters the 7-in. leads, which are in the form of horizontal bends, to the main header at the rear of the boilers through a Crane automatic stop and check valve and in the lead is also provided a bypass gate valve and the amount of steam passing through each lead is measured by a Republic flow meter with indicators mounted on the front of each boiler and recorders located in the chief engineer's office in the main building of the institution.

The main header is 12 in. in diameter and is divided into two sections by a bypass gate valve of the rising stem type thus giving an arrangement of two boilers to each section. All high-pressure steam piping is insulated with a 2-in. covering of J.-M. asbesto sponge felt, exhaust steam and hot water piping is covered with asbestocel 1 in. thick, while the covering for transmission lines is 85 per cent magnesia and hair felt.

Among the noteworthy features of this boiler plant is the record system employed, which, with the exception of the readings of the makeup water meter, is entirely graphic. In Figs. 13 and 14 are shown one day's records with the exception of the tickets from the coal scales. On this day, only boiler No. 1 was in operation, which accounts for the single record on the chart from the Hays $CO_2$ and draft recorder.

At the present time, this new boiler plant furnishes the steam for driving the old electric generating plant, which has an installed capacity of 555 kw., including both alternating and direct-current generators. Plans for the future, however, call for an entirely new building and equipment which will be an extension of the present boiler house.

A. W. Grabe, of Milwaukee, was retained as consulting engineer on this plant and M. J. Morehouse, of Chicago, as the architect, while the chief engineer of the plant during most the time the plans were being made and installation work done was Bert E. Clough; but since last April, John R. Carter, who had much to do with the new work on the plant, has assumed responsibility as chief engineer.

# Temperatures and Gas Velocities in Boiler Settings

RESULTS OF TESTS ON 1000-HP. STIRLING BOILERS. BY A. W. BINNS AND C. E. JOOS

A TEMPERATURE CHART was taken on a 1000-hp. Stirling boiler by a recording Brown pyrometer.

The thermocouple was placed at various points as designated on Fig. 1, by the letters, a, b, c, etc.: the curve, Fig. 2, was plotted from the values obtained.

In studying the gas velocities, the average combustion rate of 32 lb. of coal per square foot grate surface per hour was taken. The analysis of flue gas gave $CO_2$, 12 per cent; CO, 0 per cent; $O_2$, 8 per cent; $N_2$, 80 per cent; under these conditions, the pounds waste gas per pounds of coal equals 16.

Referred to 32 deg. F. and atmospheric pressure, Kent gives the following as the weights of the gases:

1 cu. ft. $CO_2$ weighs 0.122,67 lb.
1 cu. ft. $O_2$ weighs 0.089,21 lb.
1 cu. ft. $N_2$ weighs 0.078,31 lb.

Converting the gas analysis by per cent volume to per cent weight:

$CO_2 - 0.12 \times 44 = 5.28$
$O_2 - 0.08 \times 32 = 2.56$
$N_2 - 0.80 \times 28 = 22.40$

30.24

Therefore the per cent by weight is:

$CO_2 = 5.28 \div 30.24 = 17.6$ per cent
$O_2 = 2.56 \div 30.24 = 8.4$ per cent
$N_2 = 22.40 \div 30.24 = 74.0$ per cent

The total weight of one cubic foot of flue gas will equal:

$CO_2 - 0.122,67 \times 0.176 = 0.0216$
$O_2 - 0.089,21 \times 0.084 = 0.0075$
$N_2 - 0.078,31 \times 0.740 = 0.0581$

0.0872 lb. per cu. ft. total

As the above figure, 0.0872, is the weight of one cubic foot flue gas at 32 deg. F. atmospheric pressure, it

is necessary to consider the temperature changes in the boiler setting to obtain the true weights at different points.

Assume our average conditions:

32 lb. coal per sq. ft. grate surface per hour with 262 sq. ft. grate surface. Total coal per hour equals 32 × 262 = 8384 lb. and at 16 lb. waste gas per pound of coal, a total gas going through the setting equals 16 × 8384, or 134,144 lb. per hr. Therefore the cubic feet per hour at 32 deg. F. and atmospheric pressure equals 134,144 ÷ 0.0783 equals 1,710,650.

Referring to Fig. 1, the temperatures of the various points are as follows:

1, 1800 deg. F.; 2, 1000; 3, 900; 4, 800; 5, 700; 6, 7, 8, 9 and 10, 600; 11, 12, 13, 14 and 15, 400 deg. F.

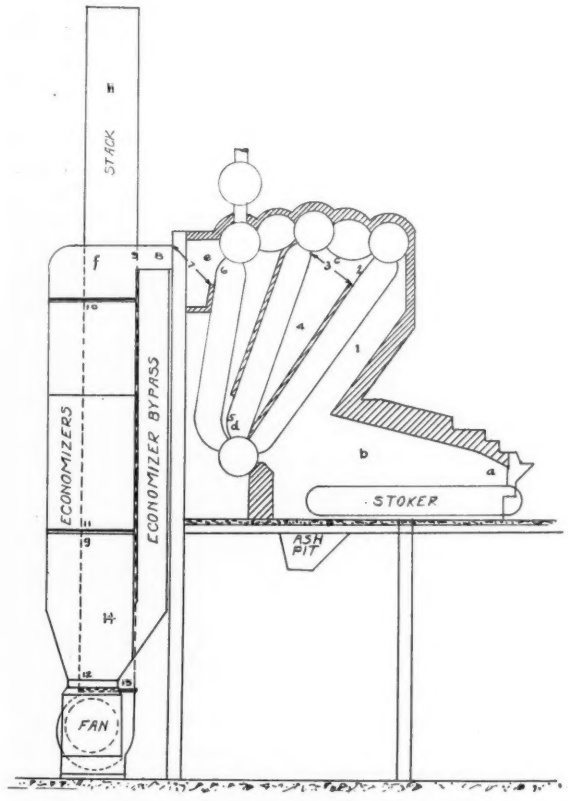



FIG. 1. CROSS SECTION OF BOILER SETTING TESTED FOR GAS TEMPERATURES

Now at these several points the volume in cubic feet, passing per hour of the same total weight may be found by considering the flue gas a perfect gas and figuring the volume changes accordingly.

That is $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Thus at point (1) referring to 32 deg. F. and atmospheric pressure

$\frac{1{,}710{,}650}{493} = \frac{V_2}{2260}$, V2 equals 7,180,000 cu. ft. per hr.

| Point in pass | Flow in cu. ft. |
|---|---|
| 1 | 7,180,000 |
| 2 | 4,570,000 |
| 3 | 4,260,000 |
| 4 | 3,950,000 |
| 5 | 3,630,000 |
| 6 etc. | 3,320,000 |
| 11 etc. | 2,640,000 |

The volume curve in Fig. 3 is plotted from these values.

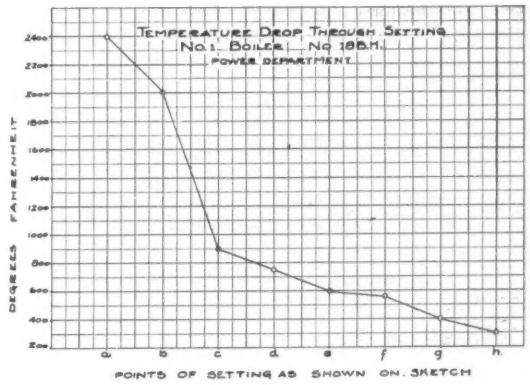

TEMPERATURE DROP THROUGH SETTING
No. 1. BOILER | No. 188 H.
POWER DEPARTMENT
DEGREES FAHRENHEIT
POINTS OF SETTING AS SHOWN ON SKETCH

FIG. 2. TEMPERATURE DROP THROUGH SETTING

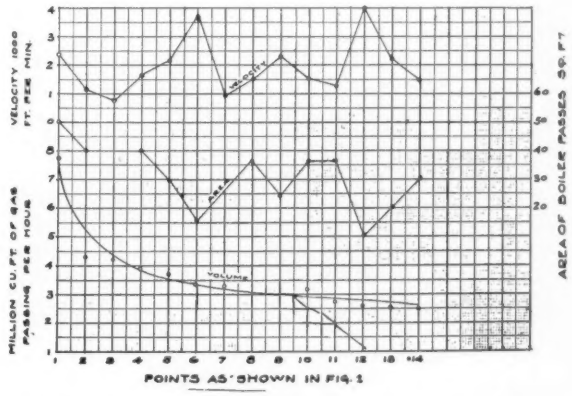

VELOCITY 1000 FT. PER MIN.
MILLION CU. FT. OF GAS PASSING PER HOUR
AREA OF BOILER PASSES SQ. FT.
VELOCITY
AREA
VOLUME
POINTS AS SHOWN IN FIG. 1

FIG. 3. RELATIONS BETWEEN AREA OF GAS PASSAGES, VELOCITY AND VOLUME

The areas of the different passes are as follows and are shown by the area curve in Fig. 3.

| | |
|---|---|
| 1—50 sq. ft. | 8—36.7 sq ft. |
| 2—40.4 sq. ft. | 9—24 sq. ft. |
| 3—90 sq. ft. | 10—36 sq. ft. |
| 4—40 sq. ft. | 11—36 sq. ft. |
| 5—30 sq. ft. | 12—10.7 sq. ft. |
| 6—15 sq. ft. | 13—20 sq. ft. |
| 7—60 sq. ft. | 14—30 sq. ft. |

From these figures are computed the velocities which are shown in the velocity curve, Fig. 4. Velocity in feet per minute equals volume in cubic feet per hour divided by square feet area of pass and the quotient divided by 60.

# Risks in Handling and Storing Coal and Oil*

EXPERIENCES WITH FIRES IN CONNECTION WITH THE STORAGE OF THESE FUELS. BY C. E. PAIGE†

WHEN COAL pile fires are mentioned, the first thought is spontaneous combustion. Some coals, on inspection, indicate that they can be stored under any condition without self ignition. Others look as if they might fire easily. The great bulk of the difficulty comes with coals which do not appear dangerous until the fire actually starts.

Anthracite coal gives no trouble in storage, gas coal of reasonably good quality rarely gets afire. The great risks are in bituminous and semi-bituminous coals of poorer quality. Market and other conditions make it necessary at times to handle coals that may take fire. Usually the fire comes as a surprise. It is well, therefore, to take precautions in all cases where there is the slightest question as to the origin or quality of the coal.

When, and if, a fire occurs in a coal pile, the dangers are of two kinds,—loss in value of coal, and the hazards of workmen dealing with the problem. Fire risk may be reduced if precautionary facilities are provided and used. There is no danger of spontaneous combustion if suspected coal is stored under water. Such storage, however, is not always practicable. Coal is less likely to fire if stored under cover of a shed with air-tight sides and a good flooring. The risk is reduced if coal can be unloaded without breakage, which often exposes new surfaces to the air and permits heating.

Some years ago we had a pile of steam coal, about 5000 tons, unloaded from a wooden trestle 22 ft. high. The coal had been boomed over from the track by a locomotive crane grab bucket into a pile about 20 ft. deep. It began to heat and we opened the pile, but owing to lack of time and space, we were unable to do the work thoroughly. Our effort reduced the combustion but did not stop it. We began using water from a fire hydrant, which, when used in small quantities for local burning seemed to extinguish the fire in one spot, but a little later all the coal around this spot began heating rapidly. Then we began soaking the pile, day and night, until finally the coal became so wet that the heating stopped. We do not believe that this treatment would be effective for dealing with fire in larger piles, nor with all kinds of coal. When there was no more indication of heat, we shut off the water, but, in a few days, the pile began to heat again, and we put on the water again. The menace was not eliminated until the coal was used in the boilers.

A year ago now, we in New England were scrambling for an adequate gas coal supply. We were paying all kinds of prices for any kind of coal, buying from many sources and receiving all coal into one shed, which made separate storage out of the question.

Our shed is built with reinforced concrete plaster sides, tile roof and an oak floor. The coal is dumped from a trestle 18 ft. high, and is reclaimed by an overhead crane. Our pile showed signs of heating, but no particular precautions had been taken because we had never before experienced any trouble with gas coal. The crane operator saw little spurts of smoke and steam issuing here and there from the pile, and there was also noticeable, the acrid smell due to slow combustion.

We began using the coal from this part of the pile, and handling over the stock, where in one end of the shed the fire was concentrated. In spite of rehandling, the zone of combustion began spreading, and to prevent its getting to the main pile, we dug a deep trench through the middle of the shed, making practically two piles. We had already demonstrated that while the better coal did not show signs of heating by itself, it began to heat if in contact with coal of poorer quality.

We then opened the sides of the shed and moved a large part of the suspected coal out, piling it in heaps not more than 4 or 5 ft. deep. In this way, we isolated certain parts of the pile which were active, and quenched the fire with water. Here again, we found that the real cure was getting rid of the coal.

One feature of dealing with this fire which made our work so difficult was the problem of shed ventilation. The fumes from the fire, with the steam vapor, made a condition which was most uncomfortable. One could not see more than a few feet and the foul air affected the men in some cases; in fact, we had to cut holes in the shed to provide additional ventilation, in spite of which the men had to wear masks at certain times.

From these experiences, we learn that there are no known guarantees against this trouble. We recognize, though, that the risk may be mitigated by observing, when it is possible to do so, a few simple rules which have been formulated by the Bureau of Mines.

## OIL

GAS OIL is a raw material which should offer little menace as a fire hazard, provided the simplest precautions are observed. I quote from an authority on the subject:

"The storage of gas oil in connection with gas manufacturing plants should be in steel tanks with tight steel roofs. Underground concrete tanks are suitable and safe, but the expense is usually prohibitive, unless real estate is limited. Steel storage tanks used for gas oil should be of a heavier design than is common in ordinary oil field practice. I would recommend that they be designed with a safety factor not less than 3 when fully loaded with water. The roofs should also be heavier than usual oil field practice, and I would recommend that the roof plates be not less than 3/16-in. thick. The lighter roofs usually furnished on standard tanks are subject not only to quicker corrosion, but also will not remain tight in service. All fittings on the tanks, such as nozzles for connecting pipe lines, should be of cast steel. There should be swinging joists in all the pipe lines that connect to the sides of the tank, and double valves are a wise provision. There should be no bottom connections.

"The vent from the tank should be properly screened and frequently inspected so as to insure that the screen is neither clogged or corroded.

"Storage tanks should be as remote from operating buildings as is possible on the plant sites involved, and

* Abstract of paper presented before the Public Utilities Section of the Tenth Annual Safety Congress of the National Safety Council.

† Manager, Worcester Gas Light Co., Worcester, Mass.

should in any event be surrounded by emergency dikes which would impound the contents of the tank in event of its collapse. Where the real estate is available, earth dikes 6 to 8 ft. high, forming a basin which will hold 50 per cent more than the capacity of the proposed tank, are the cheapest and best protection. Where the real estate is limited, concrete dikes, or even steel dikes, may be used, but I personally am not inclined to favor the steel dikes as they are likely to be destroyed by the heat from the burning oil. I consider that the diameter of the dike wall, if high and made of either steel or concrete, should be at least 50 ft. greater than the diameter of the enclosed storage tank. Between the shells of adjacent tanks there should be a space not less than the National Board of Fire Underwriters require for fuel oil storage.

"The tank should be thoroughly grounded and all openings except the screen vent be made perfectly tight. With these precautions there is little likelihood of ignition by lightning even if the tank is struck.

"The tanks should be equipped with a so-called safety steam line, which is merely a pipe normally empty connected to the general steam supply of the plant and having two or three, or more, inlet connections into the tank near the top angle. The valve admitting steam to this line should be not less than 50 ft. away from the tank, and preferably more. If the tank gets on fire and the roof is not blown off, the admission of steam through this safety line will put out the fire.

"The only way to put out a fire in a gas oil tank, if the roof has been blown off, is by the application of Foamite solution. Foamite solution, if properly installed and operated, is practically absolute protection against any extensive oil fire, but in the ordinary gas plant the expense involved is usually not justified because the hazard is small and the rates on insurance are not greatly reduced by installation of the Foamite system.

"It is useful to have the piping and pumping arrangements so that in the event of a fire occurring in one tank, the contents can be rapidly pumped out into another tank to reduce the loss.

"There should, of course, be ample high pressure hydrant and hose water protection for cooling the sides of any burning tank and protecting surrounding property."

As for the regulations for the storage, handling and use of heavier oils, the following are the regulations drawn up by the Boston Board of Fire Underwriters which were adopted by the Massachusetts District Police and became effective Jan. 1, 1920. They are applicable to liquids having a flash point above 150 deg. F. The regulations specify the following:

1. The circulating pump must be located above the highest oil level of the oil storage tank and all of the piping pitched, so they will drain into the storage tank.

2. The suction and discharge lines must enter and leave the top of the oil storage tank.

3. Filling and suction pipes must extend to the bottom of the oil storage tank.

4. Direct flow from an overhead tank to a surface tank is not permitted. However, this is sometimes allowed when a pump intervenes.

5. Each storage tank must be provided with a manhole and vent pipes with brass mesh screen.

6. Each storage tank must be provided with a steam fire prevention pipe.

7. Check valves must be placed in pipe lines as close to the oil storage tanks as possible to avoid siphoning.

8. Valves must be placed in suction and discharge lines to and from the storage tank, as close to the tank as possible.

9. Overhead tanks must be provided with a dike of 150 per cent capacity. The height of the dike is to be not more than one-quarter of the height of the tank. If the dike is made of earth the slope must be 2 to 1, and the pipes may not be below the top of the dike.

10. Underground storage tanks must be covered with at least three feet of earth.

11. Each installation must be approved by the authorities on its merits. In an isolated location, certain modifications of these requirements are permitted, except in Massachusetts.

Fuel oils, if used for steam purposes in boiler furnaces, offer some hazards to firemen from "flashbacks" in the burners or explosive mixtures in the furnaces accumulating before ignition.

## Tidal Power Transmission

IN A paper recently presented before the British Association, T. F. Wall makes an unique proposal to use variable speed a.c. generators giving a frequency of 400 to 800 cycles per second and supplying constant current to the line. He shows that under these conditions, by varying the voltage at the generator, that at the receiving end may be nearly constant due to inductive action, and the line will deliver current of variable frequency at constant voltage. Varying frequency will do no harm for heating or lighting use, so long as the frequency is high; and for power he proposes to convert, by means of mercury-arc rectifiers, to direct current of constant amperage and nearly constant voltage.

For frequency of 400 and 800 cycles per second the variation in generator voltage should be 37,200 and 52,000 v. respectively, and that at the secondary connected to the rectifier should be 5500 and 5900 respectively to give direct current of 2500 amp. at 2000 v. Line current is assumed at 96 amp. and transmission length at 115 mi. with conductors 0.42 in. diameter, 3-phase. To compensate for drop in distributing lines and transformers at the higher frequencies, voltage at the receiving end can be allowed to rise by a certain percentage as frequency increases; or the inductive effect can be overcome by using synchronous condensers to give leading current.

Mathematics of the discussion are given in Engineering, Oct. 21 issue.

THE Imperial Railway Department of Japan is planning to construct a great hydroelectric plant at Niiagata Prefecture, using the water power of the Shinano River, states the Far Eastern Review. The plant will have a capacity of 84,000 kw. and will operate a section of 200 mi. of line. It is expected that it will be in operation in 1926.—Commerce Reports.

A CARGO of Australian coal was recently delivered in Portland, Ore.

# Value of Intercooling Compressed Air

METHODS AND MEANS OF COOLING AIR DURING AND AFTER COMPRESSION. BY C. K. BENNETT*

COMMERCIAL air compressors are water-cooled either by injecting water into the compressor cylinders, water-jacketing the cylinder, or by compressing the air in two or more stages and cooling the air between cylinders by means of water-jacketed vessels known as intercoolers. Two of these methods are generally used together on the same compressor.

Water injection has never been extensively adopted in this country inasmuch as its use is limited by several disadvantages. The water feeding devices demand constant attention. The air becomes saturated with water vapor and this moisture increases cylinder and piston wear, and later frequently gives trouble by freezing when the air is expanded in doing work.

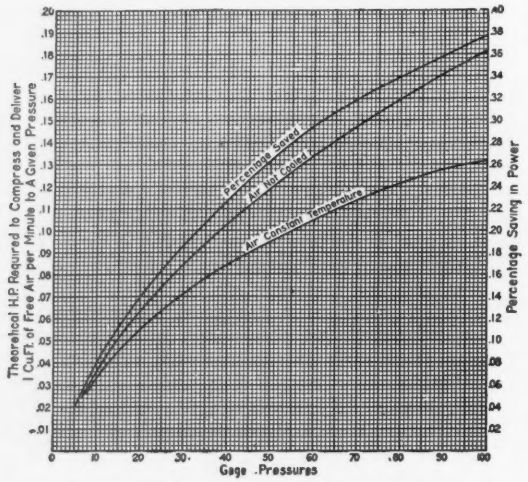

Theoretical H.P. Required to Compress and Deliver 1 Cu.Ft. of Free Air per Minute to A Given Pressure
Percentage Saved
Air not Cooled
Air Cooled Isothermally
Percentage Saving in Power
Gage Pressures

FIG. 1. THEORETICAL HORSEPOWER REQUIRED TO COMPRESS AIR

Jacketing the cylinders is simpler than either of the other cooling methods; however, it is less efficient. Since the period of compression is short and therefore only a small percentage of the total volume of compressed air, delivered at each stroke, can come into contact with the water-cooled cylinder, the cooling effect is small.

For these reasons, modern practice is to compress the air in stages, and to cool it between stages by means of efficient intercoolers. Thus the increase in pressure from atmospheric to desired delivery pressure is divided among two or more cylinders, and the temperature rise per cylinder is limited. The air is first compressed to a moderate pressure in one cylinder and thereupon passed to an intercooler wherein its temperature is considerably lowered and the volume of the air correspondingly reduced. The cooled air is then forced to the next cylinder and so on, until the final delivery pressure is attained in the last cylinder, whereupon the air is passed to an aftercooler and thence to the receiver or storage tank. The intercoolers between the cylinders and the aftercooler after the high-pressure cylinder remove most of the heat of compression.

The most important advantage of compressing the air in stages and intercooling the air between cylinders is that power is saved—particularly in instances where the compressed air is passed to a receiver in which it remains for some time before being put to use, or where the air is transmitted a considerable distance from the compressor.

Figure 1 shows the theoretical horsepower required to compress and deliver 1 cu. ft. of free air per min. to a given pressure; first, when the temperature is maintained constant during compression; second, when the air is compressed without cooling. The first process is known as an isothermal compression and is approximated by compressing in stages and intercooling; the second is an adiabatic compression, and the difference in the power requirements for the two processes is the theoretical saving in power that under ideal conditions may be approximated by means of multi-stage compression and intercooling. No allowance is made in Fig. 1 for friction or other losses.

Kent mentions that in cards taken from the 2000-hp. two-stage air compressor at the Quai De La Gare Plant of the Paris compressed air central station company, the saving realized by means of multi-stage compression and intercooling is 85 per cent of the theoretical amount. Of this 77 per cent is mainly due to intercooling the air between the two compression stages.

Another advantage of intercooling compressed air is that most of the water vapor in the air is precipitated in the coolers and for this reason trouble by freezing is avoided. This is of value, especially when the air is subsequently to be used in air agitators in ice plants,

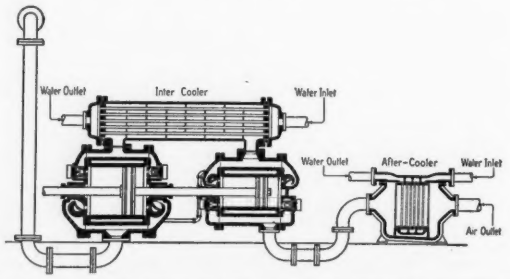



FIG. 2. TYPICAL TWO-STAGE AIR COMPRESSOR EQUIPPED WITH INTERCOOLER AND AFTERCOOLER

stone drills, riveting machines, paint guns, etc. As the air expands in doing work in the pneumatic machine, it must absorb heat; and since the process takes place rapidly or adiabatically, most of the heat is supplied by the air itself. If the air contains any moisture, this vapor will be condensed during the air expansion and the condensation will either damage the pneumatic machine, or cause other trouble as in varnish sprays where the water would be sprayed over the furniture surfaces causing bubbles and pitting. Further if moisture condenses and collects in air pipe lines, it causes water hammer, leaky joints, and loss of power by accumulating at low points and reducing the air passage.

With single stage compression without intercooling, there is always danger of an explosion due to operating conditions. The air remaining in the clearance of the

*Engineer, Schutte & Koerting Co.

cylinder is at a high temperature, and is repeatedly recompressed, raising the temperature still further until a point is reached where the lubricating oil decomposes under the heat and vaporizes. The compressed air and vaporized oil form a mixture that may explode and cause serious damage.

A typical two-stage air compressor equipped with intercooler and aftercooler is shown in Fig. 2. Air enters the low-pressure cylinder through the open inlet valve, which, at the end of the suction stroke, closes. As the motion of the piston compresses the air filling the cylinder, the discharge valve opens automatically and allows the compressed air to pass to the intercooler where it is cooled and then discharged to the second cylinder or the subsequent stage. During its passage through the intercooler the air surrenders to the water practically all the heat of compression although some of this heat has already been absorbed by the water in

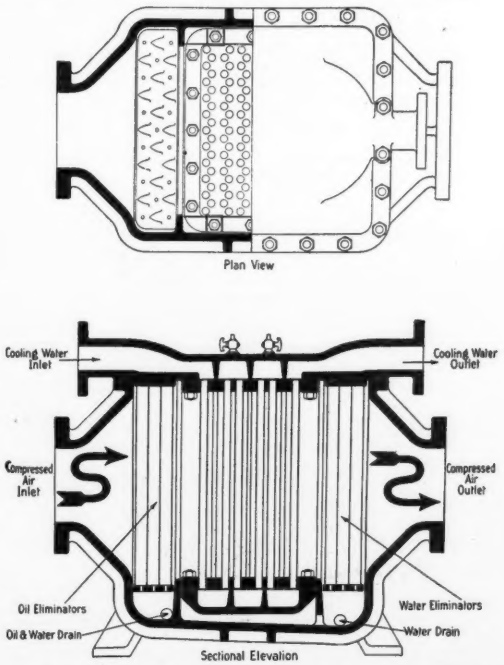



FIG. 3. SECTIONAL PLAN AND ELEVATION OF INTERCOOLER

the compressor water jacket. After the air leaves the last stage, it is usually conducted to an aftercooler, where the heat generated in the final stage of compression is removed in exactly the same manner as in the intercooler. The cooled high-pressure air is then passed to the receiver where it is stored until drawn off for use as required.

A sectional elevation of a typical intercooler is shown in Fig. 3. The air is carried around the outside of the tubes, and the cooling water through the tubes. As it is a simple matter to clean the inside of the tubes, very dirty water can be used. The current of air drawn across the tubes is continuously divided or sliced into thin sheets or films, due to the close tube arrangement. Sluggish air flow or eddy currents are avoided. The air is brought into intimate contact with the tubes and a rapid and efficient absorption of the heat is effected. The use of straight tubes and the ease with which the cover plates can be removed contribute to rapidity and readiness in cleaning the cooler of scale deposited from the water. Any tube can be plugged or replaced without disturbing the others. Notwithstanding the small dimensions of the apparatus, the resistance to flow is low, and large quantities of air can therefore be handled with small frictional losses. Both oil and water eliminators are provided—thus practically all of the entrained moisture and oil is removed from the air. The importance of this has already been considered.

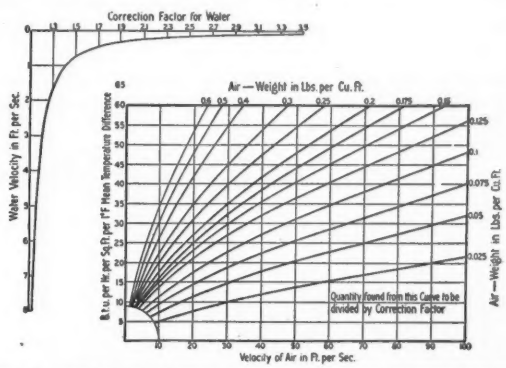

Correction Factor for Water
Water Velocity in Ft. per Sec.
Air — Weight in Lbs. per Cu. Ft.
B.t.u. per Hr. per Sq. Ft. per °F. Mean Temperature Difference
Air — Weight in Lbs. per Cu. Ft.
Quantity Found from this Curve to be divided by Correction Factor
Velocity of Air in Ft. per Sec.

FIG. 4. HEAT TRANSFER CURVES FOR AN INTERCOOLER

Figure 4 is of interest inasmuch as it gives the heat transferred in B.t.u. per hour per square foot of cooling surface for 1 deg. F. mean temperature difference between the air and water corresponding to different air and water velocities. The density of the air passing through the cooler generally varies from 0.6 to 0.025 lb. per cu. ft. Thus, for an air velocity of 50 ft. per sec. and for an air density of 0.2 lb. per cu. ft., the heat transfer rate is, from the curve, about 48. This value,

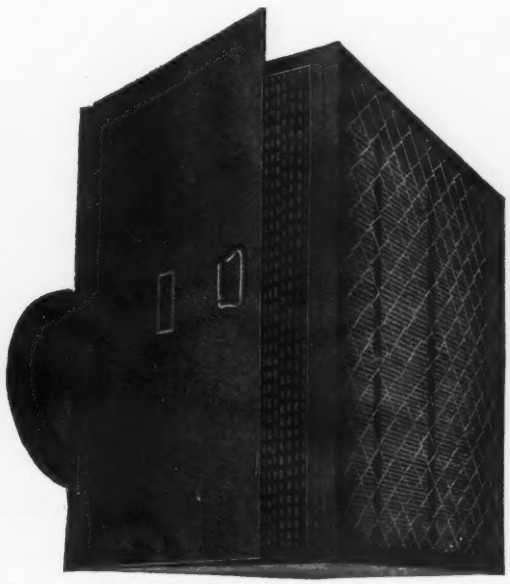


FIG. 5. TYPICAL DRY AIR FILTER

however, must be corrected for the velocity of the water. Assuming the latter to be 1 ft. per sec., the correction factor from the curve is 1.4. Therefore 48 divided by 1.4 = about 34, or the corrected heat transfer rate for a water velocity of 1 ft. per sec., an air velocity of 50 ft. per sec., when the density of the air is 0.2 lb. per cu. ft.

Frequently the atmospheric air around power plants

contains large quantities of dust and dirt and must be filtered before it is drawn into the air compressor. A typical dry air filter is shown in Fig. 5, and consists of a box open on two opposite sides for the admission and discharge of the air. Inside the filter are a number of vertical frames, the openings of which are so dimensioned that any given velocity of air flow can be obtained. The frame is built in a rectangular shape to which are fastened many fine parallel cotton threads forming the openings of the filter. The open sides of the filter box are protected by wire screens.

Unless coal dust and dirt are removed from the air, they will enter the compressor cylinder, adhere to the oil film, and the combined dirt and oil will under the influence of the high temperature be baked into a gritty mass and deposited on the valves, etc. Under these conditions the machine must be shut down frequently and the valves cleaned, otherwise there is danger of an explosion.

As many filter boxes as required are usually coupled together. The system occupies relatively small space and is generally arranged in a basement underneath the compressor or outside of the power house as conditions may warrant. The filter frames can be cleaned without interfering with the operation of the system—simply by opening the door and removing one frame at a time.

# Unaflow Engine Shows Low Steam Consumption

### Installation in the Plant of the Acme Wire Co. Develops Power at Low Cost

ALTHOUGH THE plant of the Acme Wire Co. in New Haven, Conn., is so located that it might readily purchase power from the outside at a relatively low cost, it is more to its advantage from a financial point of view to generate its own power and utilize the exhaust for heating. The ultimate overall economy realized justifies the operation of the plant even considering that there is practically no demand for exhaust steam during the summer months.

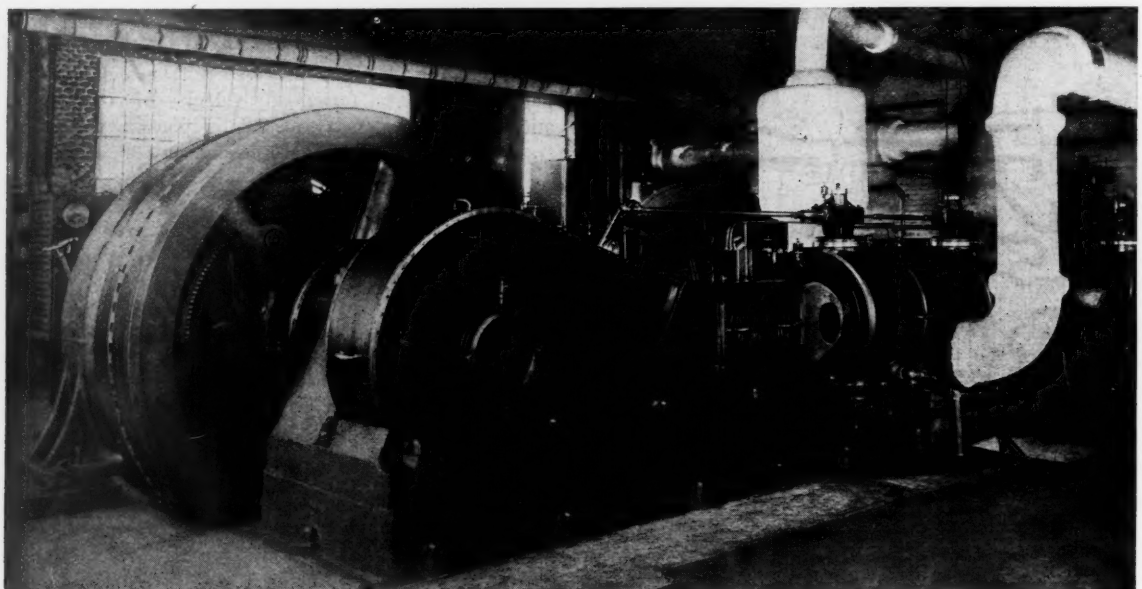


FIG. 1. ENGINE SIDE OF THE LARGER UNAFLOW UNIT

The direct current used throughout the factory is generated in a plant that is completely isolated from the rest of the buildings. It is really a small central station in itself and is conducted as such.

#### Boiler Room

Steam is generated at a pressure of 140 lb. per sq. in. gage, in three Bigelow-Manning vertical fire-tube boilers, having a total capacity, at rated load, of 550 hp. One of the battery is rated at 250 hp. and the other two, at 150 hp. each. In this type of boiler, the upper tube sheet is dry as is the upper portion of the tubes, water does not entirely cover the tubes and consequently the upper part is in contact with steam thus forming a superheating surface. With the water level at the position at which it is normally carried this superheating surface constitutes about 30 per cent of the total heating surface and is sufficiently ample to produce 20 deg. of superheat which is just about enough to deliver the steam to the engine in a dry saturated condition or with 1 or 2 deg. superheat.

The furnace settings are all built for hand fired operation, in fact, all the coal and ash handling is done manually, from coal car to ash heap. Coal is conveyed in barrows from the pile alongside the siding, and placed on the boiler-room floor, just in front of the boilers, within easy reach of the fireman. Ash is raked out from the ash pit onto the floor and carted out in barrows.

Under normal conditions, the daily, 24 hr. consumption of coal is in the neighborhood of 12.5 T. of high grade Pennsylvania washed anthracite. The refuse

handled amounts to about 1700 or 1800 lb. in the same period. The ash content runs as low as 5 per cent, but the combustible in the refuse brings the amount up somewhat.

As the plant is not located immediately adjacent to any surface water, and as it was thought inadvisable to purchase from the city, boiler feed water is obtained from a deep well by means of an air lift. The well is 750 ft. deep and requires a pressure of 75 lb. to bring the water to the surface. Air under this pressure is supplied by an 8 by 8-in. Ingersoll-Rand air compressor which is driven by a 13-hp. motor running at 1100 r.p.m. The air lift delivers the water to a surge tank from which it is pumped by an Alberger centrifugal volute pump direct connected to a 75-hp. motor running at 1425 r.p.m. to the storage tank, under a head of 100 ft.

This water is hard and in its natural state is unfit for boiler feed purposes. Tests have shown that the total hardness amounts to as much as 70 parts per million. To reduce this hardness to a point suitable for the purpose, a continuous Permutit water treating apparatus has been installed and operated with success. It is now necessary to wash down the boilers only at very long intervals, whereas, before the system was put in, one boiler had to be cleaned every week end.

Boiler feed water is heated in two 1000-hp. National feed water heaters, in series. The first is the open type and the second is closed. In the first, the cold water at about 53 deg. is heated to about 135 deg. and in the second, the temperature is further increased to about 218 deg. The pumping is done by either one of two boiler feed pumps connected in parallel between the two heaters. One is a 10 by 7 by 14-in. Davidson pump, and the other an 8 by 5 by 10-in. Marsh. Either one is sufficient to take care of the whole battery at maximum capacity, but two are installed for safety.

### Engine Room

Current is generated in three direct current generators at a potential of 250 v. The largest one of these is a Crocker-Wheeler, self excited unit which is rated at 250 kw. or 1000 amp. at 250 v. and runs at 150 r.p.m. It is direct connected to a 23 by 27-in. Ames Unaflow engine, shown in Fig. 1, built under the Stumpf patents, which operates between a head pressure of 135 lb. and 4-lb. gage back pressure. Steam is admitted to the cylinder by double beat poppet valves which are lifted by rollers on sliding bars which come in contact with the lifting cams. The valves are closed by rollers releasing cams and by the pressure of head steam, and steadied by light spring tension. The exhaust ports in the middle of the cylinder, which are opened by the piston, communicate to an exhaust belt circling the cylinder which in turn is open to the exhaust piping. Cylinder heads are steam jacketed and both heads and the walls of the cylinder are heavily insulated to reduce as far as possible the initial condensation.

The inherent feature of this design provides that the relatively cool exhaust steam does not come in contact with the hot walls near the steam jacketed heads and consequently these portions of the cylinder are kept hot which results in minimum initial condensation, a condition which greatly reduces the steam consumption. A test on this engine showed an average steam consumption over a wide range in load, of 20.5 lb. per indicated horsepower-hour.

Speed control is effected by a combination centrifugal and inertia effect shaft governor. Lubrication of the piston and cylinder is provided for by a mechanically operated lubricator, one feed of which is connected to the throttle valve and the other directly to the cylinder. Main bearings, crosshead, etc., are lubricated by a forced feed system from a large storage tank.

The second unit consists of a General Electric, self-excited d.c. generator, shown in Fig. 2, which delivers 800 amp. at 250 v. or 200 kw. to the system. It is also direct connected to an Ames Unaflow 21 by 24-in. engine similar in design to the first one mentioned. This unit runs at a somewhat higher speed: 200 r.p.m.

A Crocker-Wheeler generator having a normal capacity of 150 kw. direct connected to a Fleming-Harrisburg four-valve engine comprise the third unit which also runs at 200 r.p.m.

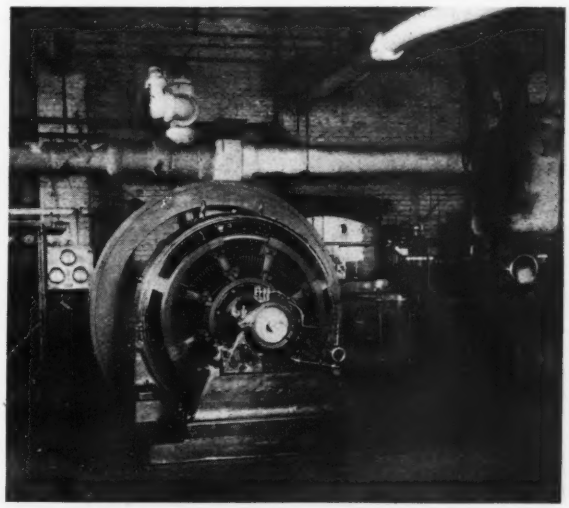


FIG. 2. GENERATOR END OF THE SMALL UNAFLOW UNIT

All engines exhaust at 4-lb. pressure into a common exhaust main which supplies the heating system of the plant. The returns are brought back through one return main which connects with the first open heater.

Generator leads are connected to a common bus on the switch board from which the factory is supplied through a simple two-wire 240-v. system.

On Saturday afternoons and Sunday, the plant is idle and the main generating units are shut down. There are, however, several lights which have to be kept going and a few small motors which are used intermittently during this time. As the outside power is alternating current, a small 18-kw. induction motor generator set is used to supply this demand.

## Feed Water Regulators in Buick Plant

Our attention has been directed to a misleading statement which appeared in the description of the Buick plant on page 839 of the Sept. 1 issue. The statement, "Copes automatic feed water regulators maintain constant water level," applies only to conditions of constant load. As soon as the load increases, however, the water level is automatically lowered; conversely, when the load decreases, the water level is raised.

# A Compressorless Diesel Engine

FUEL INJECTED WITHOUT AIR, UNDER PUMP PRESSURE; GRADUAL COMBUSTION AT CONSTANT PRESSURE; AIR COMPRESSED BY LOWER END OF PISTON; CROSSHEAD TO TAKE CONNECTING-ROD THRUST

IN THE new solid-injection oil engine of the Worthington Pump and Machinery Corporation, a new principle and cycle of action has been developed. While the fuel is injected under pump pressure, it is not sprayed into a hot combustion chamber filled with air, but into a small chamber in the cylinder head at about 450 lb. pressure. The oil is vaporized, but the air supply is so small that there is no combustion, and ignition takes place only where the vapor mixes with more air in the cylinder.

Fuel is admitted to the small chamber some time before the crank reaches dead center, is vaporized and the pressure there increased so that at about dead center the vapor mixture flows through an orifice into the cylinder where the pressure is decreasing from maximum compression, owing to the forward movement of

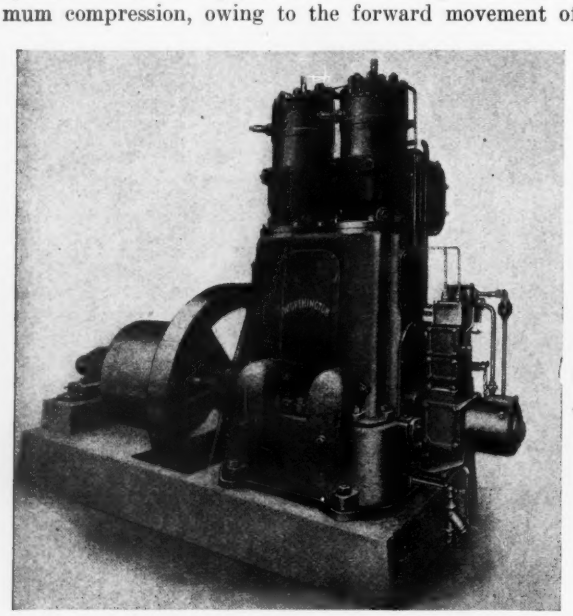


FIG. 1. WORTHINGTON SOLID INJECTION DIESEL OIL ENGINE

the piston. The size of the orifice is such that approximately 500 lb. constant pressure is maintained behind the piston while the vapor mixes with air and burns. Air is forced into the cylinder from the lower end and compressed by the piston as is usually done for the two-stroke explosive cycle.

By the means described, and the proportions of admission chamber and orifice, any chance of misfiring or irregular operation at light load is removed, and a gradual burning is achieved, avoiding high explosion pressure, for the temperature is at all times high enough to insure combustion; but the fuel comes in at a definite time in the stroke and gradually, giving complete combustion and freedom from carbon.

Water cooling of the head removes the likelihood of fire cracks, and each cylinder has a water jacket its full length.

Vertical units with one, two or four cylinders are built, cylinder sizes being designed to give 25, 40 or 60 hp. per cylinder, so that any rating from 25 to 240 hp. may be provided. In appearance and design, the Worthington engine is somewhat like a Diesel, but has, at the lower end of the piston rods, crossheads which the connecting rods join to the crankpins. This allows of greater piston clearance, and avoids the cylinder wear from trunk pistons. The piston on its upstroke draws air into the compression spaces, B, cored in the engine frame through Worthington feather valves at A. On the down stroke, the air is compressed to 4.5 lb. pressure,

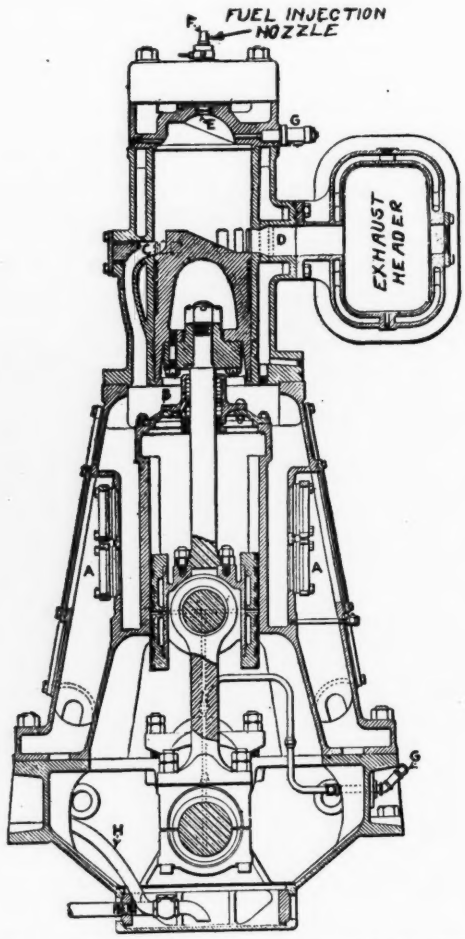



FIG. 2. SECTION OF WORTHINGTON OIL ENGINE

and when port C opens, the air sweeps the exhaust gases out of port D to the exhaust header, filling the cylinder with fresh air, which is compressed on the up stroke in the cylinder. This gives a compression system simple to operate and keep tight, without extra attention or lubrication.

The engine may be arranged for direct coupling to the driven machine, or as shown in the illustration with outboard bearing and pulley carried on a shaft which is coupled to the crankshaft.

Cylinders have four openings at the lower ends of the jackets to permit thorough cleaning, while at the

upper ends tubes in the jackets meet tubes in the heads, rubber gaskets preventing leakage. Water spaces in the heads are also readily accessible for cleaning, the system being so arranged that ports for air transfer and exhaust, and the exhaust manifold are cooled.

Pistons have the deflector usual in the two-cycle design, the piston rod being a steel forging taper fitted into a large flange which is bolted to the piston and secured by a castellated nut and cotter. At the lower end the rod is flanged for bolting to the crosshead. The rod runs through a stuffing-box in the flange at the top of the crank case, this keeping the air-compressor space tight and preventing lubricating oil from striking the lower surface of the hot piston, as well as grinding the rods.

At the crosshead end the connecting rod has a solid bronze bushing for the wristpin, while the crankpin end is a marine type box. The crosshead is turned, moving in guides bored to insure alinement with cylinder and crankpin. Crankshaft pins and cheeks are a single steel forging.

Oil is drawn from the crankcase through a strainer and forced to main and crankpin and wristpin bearings and to crosshead guides, returning to the sump below the crank case. Pistons are lubricated by oil forced by a second pump into two connections at opposite sides of the cylinder, feeding a groove turned in the cylinder bore, the connections being at all times covered by the piston so that oil cannot be forced into the cylinder. Eccentrics which drive the pumps, and cams for operating starting valves and the governor run immersed in oil.

Stroke of the fuel pump, which is in a housing and driven by an eccentric on one end of the shaft, is constant, speed regulations being accomplished by a centrifugal governor which shifts a cam to vary the time of opening of the pump suction valve.

As shown by the indicator diagram, the action in the cylinder is similar to that of a Diesel engine, but the combustion line slopes more rapidly, due to slow admission of the fuel vapor mixture and consequent gradual burning. Oil is used at 0.42 to 0.43 lb. per hp.-hr., comparable to Diesel economy.

It is anticipated that, due to the reliability at low loads as well as heavy, this design of engine can be adapted to automobile and truck service, thus making crude petroleum available as a fuel for vehicles.

# Why the Engine Used Too Much Oil

By J. B. Dillon

IT was a small plant dependent upon a gas engine for its power. As I entered the "engine room," the engineer and the proprietor were in an earnest discussion. It was plainly evident that they could not agree.

The moment the engineer saw me, he said: "Let's leave it to him?"

"All right."

"I insist that Bill is using the wrong oil and he insists that he is not, blaming the oil cup for the trouble," said the proprietor.

It was an old style, single cylinder 15-hp. gas engine and there is an oil cup at the top center of the crank shaft, the oil cup going around with each revolution of the shaft, and of course there would be an internal splash, within the cup, due to the centrifugal and tangential stress. The feed was arranged by a locking thumb screw.

The engineer had purchased a new oil cup the day previous to my arrival, because, as he said, the old one leaked so badly that after a 15 min. run, the cup would empty itself. Using the new cup did not remedy matters and it was put up to me to point out the why.

I readjusted the oil cup, filled it and the engine was started. After a run of 22 min. we stopped her, and the cup was empty.

The engineer smiled and the boss looked worried.

"I'm afraid your oil is too thin," I remarked.

"You're wrong. I've been using that same grade of oil for years," said the engineer.

"Let me see the container."

The marks were all right, but inquiry elicited the fact that to clean up, the oil had been poured from a number of half filled cans into the present one.

"Well, Bill, I do not like to discount your approval of the oil (taking some in the palm of my hand and pinching it, a hurried test for viscosity), but I'm afraid that somebody has mixed the dynamo and engine oil, and what you have is just honest to goodness generator oil."

"Oh no, they couldn't fool me."

The boss, who had been a silent listener, retorted: "Well, Bill, I know damn well that new oil cup is not bad, even though the old one did leak slightly."

Not caring for the two friends to get at "loggerheads," I intruded. "Tell you what I'll do. Bill and I are going over to the power plant and talk this over. She will be all right upon our return. Come on, Bill."

As soon as I got Bill outside, I said:

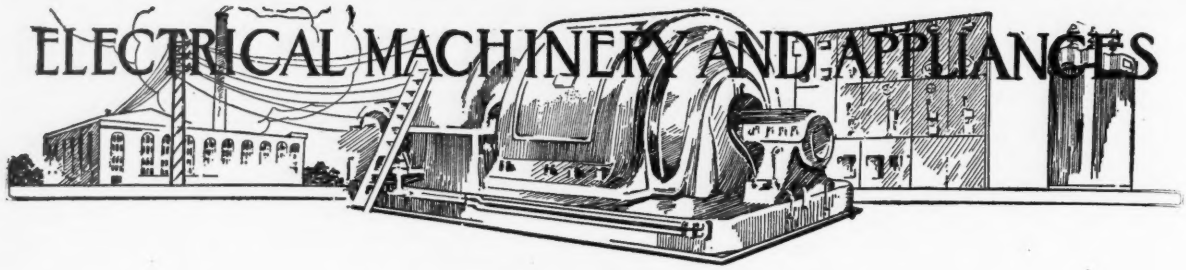
"There's no need to go to the power plant. Come in here." Entering a small factory where there was an engine similar to Bill's, I told the engineer we were having a little discussion about engine oil, and asked permission to look his over. It proved to be the same brand that Bill thought he was using. A few drops in the palm of my hand convinced me that the problem had been solved.

Borrowing from the man a small bottle of the oil for a test, we were soon back in Bill's little playhouse, and unknown to the boss I used the borrowed oil and started her up.

Bill insisted that we stop her after a half hour run, claiming that he did not care to run that shaft hot; he was sure that the cup would be empty. She was stopped and the shaft was cooler than Bill when he found that there was not enough dripped out to be really noticeable.

She had now run for 3 hr., just a fractional part of the oil having been used. The boss smiled his appreciation and Bill just insisted that he (Bill) was a plain fool or he would have had sense enough to try that stunt.

Never be too sure when things do not act to suit you. Make tests. Snap judgment is often as bad as the measles.




# Lightning Arresters---II

A Discussion of the Operating Characteristics of Various Types of Lightning Arresters and Considerations Which Govern Their Selection. By V. E. Johnson

THE ARRESTERS we have so far considered have, with one or two exceptions, been single gap arresters; that is, the discharge had to pass through one gap only before reaching the ground. We now come to that class of arresters known as "multigap"—and which forms the great majority of arresters in use today.

In Fig. 23 is shown a schematic drawing of the simplest form of multigap arrester. The advantages of this form over the single gap are in general as follows: The flash over voltage of a multigap arrester is lower than that of a single gap arrester having the air gap length equal to the sum of the gaps in the former. This may be explained as follows:

A multigap arrester is in effect a condenser with several plates in series, the arcing cylinders acting as the plates and the air forming the dielectric. The cylinder

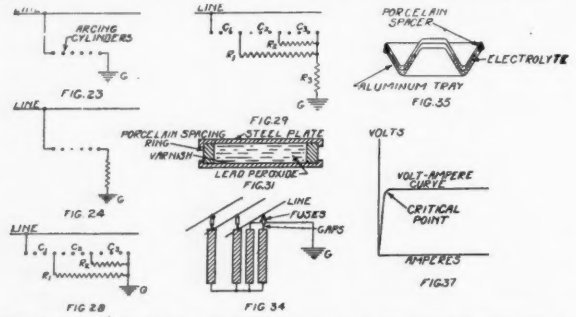



FIG. 23. DIAGRAM OF SIMPLE FORM OF MULTIGAP ARRESTER
FIG. 24. DIAGRAM OF MULTIGAP ARRESTER WITH SERIES GROUND RESISTOR
FIG. 28. DIAGRAM OF GRADED SHUNT ARRESTER
FIG. 29. DIAGRAM OF GRADED SHUNT ARRESTER WITH GROUND RESISTOR
FIG. 31. DIAGRAM OF OXIDE FILM ARRESTER
FIG. 34. SCHEMATIC VIEW OF OXIDE FILM ARRESTER ON 3-PHASE CIRCUIT
FIG. 35. CROSS SECTION OF TRAYS SHOWING SPACING
FIG. 37. CHARACTERISTIC CURVE OF THE ELECTROLYTIC ARRESTER

nearest the line is at the highest potential and the charge induced in each succeeding cylinder is less than that in the preceding one. The air gap at the line end is under more severe strain than that at the ground end, and upon a rise of voltage breaks down first. This imposes line voltage on the second cylinder, and the second gap breaks down next, this action continuing until the arc reaches ground. As soon as this happens a flow of electricity has been established and the drop across the various gaps becomes equal. The result is that the arc resistance becomes that of the single gap. Furthermore, the arc is split up into a number of sections, each of which is brought into intimate contact with a large cold body of metal which cools the bases and helps extinguish the arc. A third consideration is that the cylinders are made from non-arcing metal, which liberates zinc vapor when heated. This zinc vapor resembles, in its effect on the arc, mercury vapor, and by its unidirectional characteristics prevents the reversal of the current and so extinguishes the arc at the first zero point.

We thus find that by merely substituting for one gap, a series of gaps, we have materially improved the arrester characteristics.

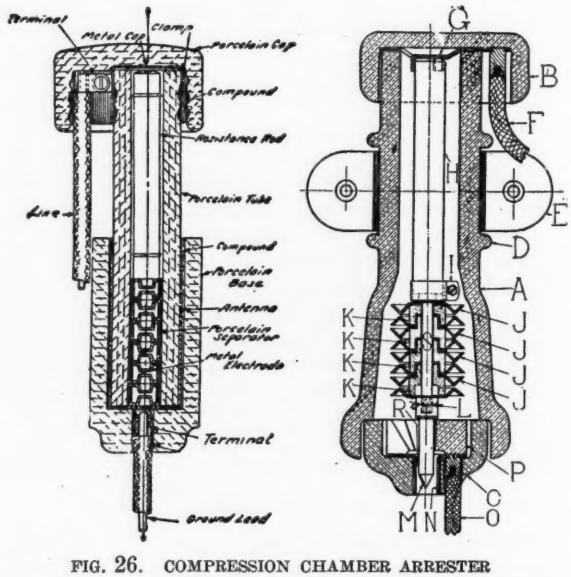



FIG. 26. COMPRESSION CHAMBER ARRESTER
FIG. 27. FORM OF MULTIGAP ARRESTER WITH GROUND RESISTOR

Arresters of this type cannot be used on direct current, as they depend for their action to a large extent on the "zero point" in the alternating current wave. They are for use on series street lighting systems, and on small distribution systems. Having no ground resistance, the gaps must rupture the power current unaided and the arrester is therefore limited in its application.

The logical step following the adoption of the multigap principle, would be the addition of a ground resis-

tance to limit the rush of power current to the ground—and so make the device of unlimited application. This is shown diagrammatically in Fig. 24. Commercially a great number of multigap arresters with series resistance and various other modifications have been developed.

The problem of providing a cheap and durable resistance resulted in the development of a composition rod, which resembles carbon—has a high resistance, high current capacity and is not affected by repeated heating and cooling. It is usually made in the form of rods with metallic ferrules, and is connected by means of clips resembling fuse clips. Broken rods can be easily changed.

In Fig. 25 is illustrated an arrester which uses disks in place of knurled cylinders. It is arranged for suspension in place of cross arm mounting. The outdoor type has a cone-shaped rain shield.

An arrester operating on the same principle as the preceding, but having a few additional features is shown in Fig. 26 and is known as the "compression chamber" arrester. The section and "opened" cut show the construction very clearly.

The "antennae" shown reduce the flash over voltage and permit the use of more gaps for a given line voltage. These additional gaps assist in the rupturing of the power current to ground. The rupturing capacity is

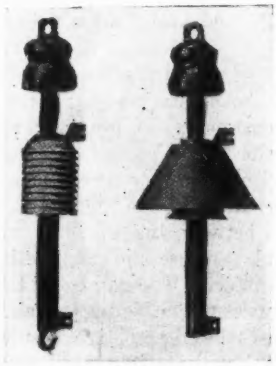


FIG. 25. SERIES ARRESTERS USING DISKS IN PLACE OF CYLINDERS

also increased by the method of installing the gaps. It will be noted that each gap unit is in a small chamber by itself. This confines the uni-directional zinc vapor and makes it somewhat more effective than if the gaps were in the open. Furthermore, the heat of the arc heats the air in each chamber and so increases the pressure, this condition also favoring the rupturing of the power current.

Figure 27 is another interesting example of a multigap arrester with ground resistor. The assembly is readily understood by a glance at the sectional view. The letters indicate the following:

A—Porcelain barrel or housing.
B—Porcelain cap.
C—Porcelain bottom plug.
D—Shoulder for holding strap E.
F—Line lead.
G—Strap connecting F to resistor H.
I—Clamp for upper end of gap unit.
J—Discharge plates or discs.
K—Porcelain spacers.
L—Threaded shank for supporting discharge point M.
N—Brass tube connected to ground line O.
P—Porcelain block holding M out of contact with N.
R—Annular air passage discharging into space between M and N.
I—Insulating rod supporting gap members.

The lightning disturbance passes through rod H, over gaps JJ and jumps to ground through the annular air space between M and N. A heavy flow of power following a discharge is interrupted by the rush of air from the large interior air spaces, out through the space around M. This "expulsion" principle in conjunction with the action of the unidirectional action of the vapor in the gaps forms an effective means of cutting the power current and the manufacturer claims that he is for that reason able to use fewer gaps and a lower resistance in the ground line; this in turn giving higher discharge capacity.

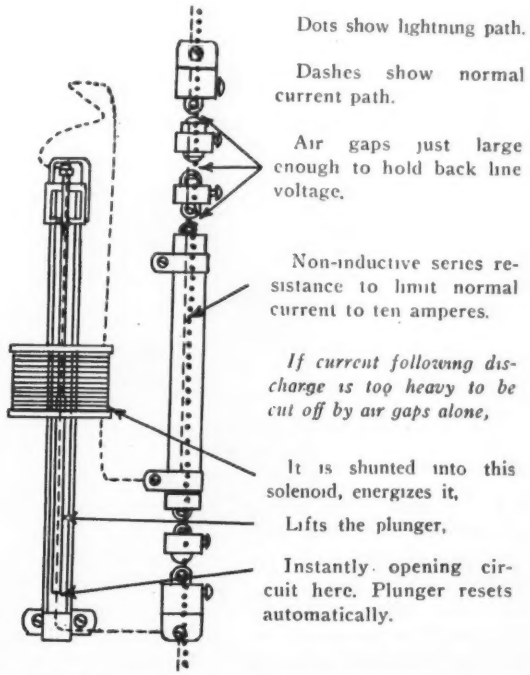

Dots show lightning path.
Dashes show normal current path.
Air gaps just large enough to hold back line voltage.
Non-inductive series resistance to limit normal current to ten amperes.
*If current following discharge is too heavy to be cut off by air gaps alone,*
It is shunted into this solenoid, energizes it,
Lifts the plunger,
Instantly opening circuit here. Plunger resets automatically.

FIG. 30. MECHANICALLY OPERATED LIGHTNING ARRESTER

There are many other variations of the multigap arrester with ground resistance, but it is impossible to list and describe them all here.

### GRADED SHUNT ARRESTERS

WHEN THE disturbances to be relieved are too large to be handled by a multigap and resistor arrester such as those described above, or when the value or importance of the apparatus justifies a more expressive installation, an arrester based on the principle shown in Fig. 28 may be made.

The type is known as a graded shunt arrester and operates as follows:

A light static discharge flows through gaps $C_1$, thence through resistance $R_1$ to ground. The power current across the gaps $C_1$ is limited by the resistance $R_1$ to a value that can be interrupted.

A medium discharge flows through gaps $C_1$ and $C_2$, and thence through $R_1$ and $R_2$ to ground. The power current will not hold an arc in the gaps $C_2$—is diverted to the path $C_1$ $R_1$ and is broken.

A heavy discharge flows through gaps $C_1$ $C_2$ and $C_3$ direct to ground. The power current following is diverted into the path $C_1$ $C_2$ $R_2$ and then into the path $C_1$ $R_1$, and is immediately cut off.

Obviously these arresters have very great discharge capacity, having no limiting ground resistance, and have in addition fairly high rupturing capacity. This capacity is, however, limited as has been previously pointed out. One manufacturer limits the use of shunted gap arresters to circuits connected to a generating capacity of not more than 2000 kv.a., with some allowances for transformer connections, etc.

In order to make this arrester one of "unlimited application," a ground resistor must be added, and we have an arrangement illustrated in Fig. 29. The addition of the $R_3$, however, reduces the discharge capacity, but increases the rupturing capacity by limiting the flow of current.

It is generally conceded that arresters of this so-called "low equivalent" type and the "shunted gap" arresters afford excellent protection and are suitable for

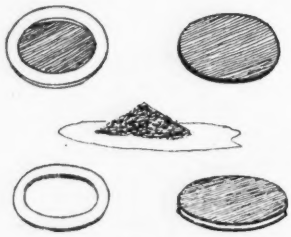


FIG. 32. OXIDE FILM ARRESTER BEFORE AND AFTER ASSEMBLY

use in locations where service is arduous, but where the first cost must be kept down.

In our discussion so far we have considered only arresters which have no moving mechanical parts. There are, however, a number of excellent arresters which rupture the power current following a lightning discharge, by means of a current breaker.

Figure 30 is a semi-diagrammatic cut of an arrester operating on this principle. The notations on the cut indicate its operation.

We now come to a group of arresters which may be broadly designated as "chemical" arresters. Under this head there are in commercial use today two types—the oxide film and the electrolytic; the latter is at the present time the highest type of arrester known.

### Oxide Film Arrester

THE OXIDE film arrester consists essentially of a horn or sphere gap in series with a number of oxide cells. These cells are about 7½ in. in diameter and consist of an assembly of two circular sherardized steel plates separated by a porcelain spacing ring, the space so formed being filled with powdered lead peroxide. Figure 31 shows roughly this arrangement, while in Fig. 32 is shown the cell before and after assembly. Figure 33 is a cut of an arrester for three-phase service assembled.

The operation of the arrester as explained by the manufacturer is about as follows:

Each cell is a valve which opens at a certain critical voltage and automatically closes when the voltage falls below this value. From Fig. 31 it can be seen that each cell consists of the following elements in series: Metal disk( conductor), varnish film (insulator), lead peroxide (conductor), varnish film (insulator), metal disk (conductor). In order for the current to pass through a cell, it must puncture two varnish films; having done that, the lead peroxide forms a free passage. This, then, is the "opening" position of the valve action. The valve having been opened, the disturbance is discharged to ground, and the power current attempts to follow. The heat generated by it, however, is concentrated in the lead peroxide at the points where the varnish film was punctured, and changes the filler at these points to red lead —which is an insulator. In other words, the flow of current immediately seals the hole through which it passes —and the "valve" is closed. Repeated discharges make a series of new holes, and these again are in turn sealed by the red lead formation. In long service, the entire surface of the metal plates may become coated with red lead. When this stage has been reached, the breakdown voltage per cell will be higher than at first, because the red lead has a higher breakdown value than the varnish films. Continued operation will result in a gradual thickening of the red lead, and will in time necessitate replacement.

The number of cells in series on a given installation will, of course, be determined by the line voltage. In service, it is customary to use four stacks for three-phase service, the fourth stack being connected between the ground end of the other three and the ground load, as shown schematically in Fig. 34. This gives two stacks in series between line and line, and also between line and ground. A fuse and gap are in series between the line and the stack. The gap keeps the arresters from being under constant line voltage strain, while the fuse protects against the destructive results of long continued discharges which might in a comparatively short time destroy the varnish films on the arrester.

The gap used is either horn or sphere, depending on the voltage. The advantages of the sphere gap have already been discussed.

The oxide film arrester fulfills very satisfactorily the six requirements outlined at the beginning of this paper. It has a good impulse ratio, free discharge, and great rupturing capacity. It has no discharge horns that set up high frequency oscillations while functioning, does not require attendance, means are provided for determining its condition, and it has low maintenance cost.

### Electrolytic Arresters

THE SECOND ARRESTER of the chemical type is the electrolytic or aluminum cell arrester. This is generally conceded to be the highest type of arrester so far developed; but its high cost limits its use to the more important installations, bearing in mind, however, that the importance of an installation is only partially determined by the cost of the apparatus to be protected.

In a general way, the action of the aluminum arrester may be compared to the action of the oxide film. It, too,

consists of a series of elements which have a positive valve action, opening to excessive voltages, and effectively shutting off any power current tending to follow the lightning discharge.

The arrester is made up of a number of aluminum trays nested one inside of the other as in Fig. 35. Each tray is separated from the next by a porcelain spacer, and is, as the cut shows, partially filled with a liquid called electrolyte. The nested trays are stacked as shown in Fig. 36, and the whole placed in a tank filled with transformer oil. This serves to conduct the heat generated away from the active material to the tank sides, where it is dissipated. The electrolyte, being heavier than oil, stays at the bottom of the trays.

The action of the aluminum cell arrester depends on the properties of a film which is deposited on the surface of the trays by the passage of the current through the electrolyte in contact with them. This film has very peculiar electrical characteristics, changing its resistance by the flow of electricity with the variation in voltage and frequency of the impressed potential. Thus, for normal voltage per tray, and normal frequency, the resistance is extremely high, while to high frequencies and abnormal voltages the resistance is very low. This will be better understood by referring to Fig. 37 which shows the relation between impressed voltage and current.

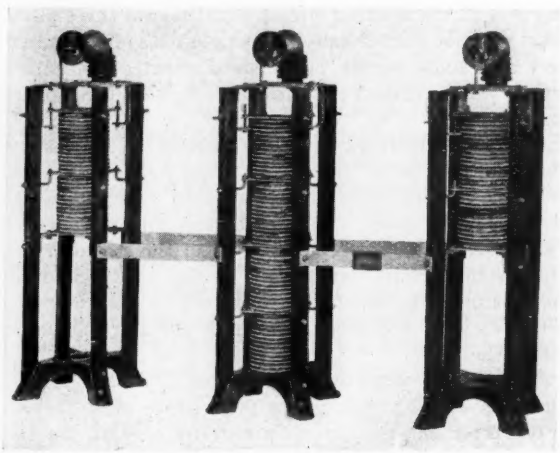


FIG. 33. COMPLETE OXIDE FILM ARRESTER FOR 3-PHASE SERVICE

It can be seen that up to the critical point of voltage the current increases but little, but that at this point the volt-ampere curve bends very sharply and the current becomes practically that of short circuit conditions. Each tray has a critical voltage value dependent somewhat on the composition of the electrolyte, and a sufficient number in series must be provided so that each tray does not exceed its critical point under normal conditions.

Each tray has a considerable surface area, and the capacity is therefore considerable. If the stock of trays were connected directly to the line, there would be a constant leakage to ground because of this capacity or condenser effect, and also because the resistance of the film, while high, is not infinite. A gap must therefore be provided between the line and the first tray. If this gap is of the type shown in Fig. 18, page 1057 November 1 issue, the accuracy of the arrester is very high, and its selective action for high frequencies remarkable.

If the arrester trays stand idle—with no current flowing through them—the film dissolves and its properties are lost. For that reason, the arrester must be "charged" daily by short-circuiting the gaps and impressing line voltage (through a charging resistance which limits the current if the film has become dangerously thin) on the stack. This takes but a second or two and re-establishes the sensitive film on the tray surface.

In order that the reader may appreciate fully the qualities of the electrolytic arrester, a detailed comparison with the qualification previously enumerated will be given.

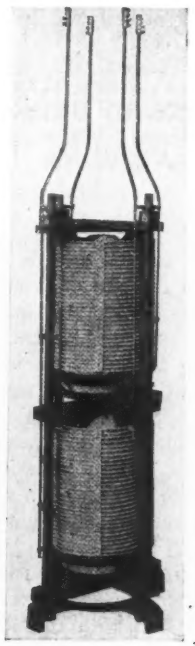


FIG. 36. ASSEMBLED ARRESTER BEFORE BEING PLACED IN TANK

1. Accurate and sensitive. In combination with an impulse gap, the arrester will discharge high frequency disturbances at 0.6 to 0.7 of normal voltage. This is due to the combined action of the gap, already explained, and the condenser action of the trays, which of course is more pronounced at high frequency. The volt ampere curve (see Fig. 37) is very definite so that there is a clearly defined critical point for each arrester.

2. Discharge capacity. After the knee of the volt ampere curve has been passed (at which point the film breaks down) the resistance to ground is almost zero so that the discharge capacity is extremely high. The oil in the tank absorbs and dissipates the heat of the discharge, thus the arrester will be uninjured by severe rushes of current persisting for considerable length of time.

3. Rupturing capacity. The volt-ampere characteristic is very stable, and as soon as the voltage drops below the critical point, the minute punctures in the film close and the power current stops.

4. The power current is not broken by the dying of the arc on horn gaps, and hence sets up no secondary disturbances.

5. The condition of the apparatus is readily determined. An experienced operator can tell by the nature of the arc caused by the charging process the condition of the film and can further check this by means of a meter which measures the charging current.

6. The maintenance cost is very low.

From the foregoing, it would seem that aside from cost and space considerations, the electrolytic arrester approaches very near to the ideal.

The engineer who is facing a problem of designing a lightning protection layout can do no better than refer it to a number of responsible manufacturers, giving them complete data on both line and station equipment. They will gladly give him expert advice—and recommend equipment suitable from both the operating and investment standpoints.

# Some Pointers on Induction Motor Troubles

By W. B. DeMuth

SINGLE-PHASE operation of an induction motor sometimes leads to not a little mystery until the reason has been discovered because of the erratic behavior of the motor under load and starting.

If one fuse blows in a three-phase circuit, the induction motor continues to run at normal speed provided the load is comparatively light, say, not more than half full load. The slip increases, also the power factor decreases and the efficiency, which varies almost directly with the power factor. If the fuse is not renewed, the motor will continue to operate as a single-phase motor. It may start from rest or may not, depending upon conditions.

A three-phase induction motor running single-phase has much lower synchronizing power than when running three-phase, so that with full load the speed will decrease. The motor may even stall and stop altogether. The writer has seen motors on several occasions where blowing of a fuse or other interruption in one phase has caused the motor to stall on single-phase current. The heavy current rush causes excessive heating which may often leave its impression on the rotor. Have you ever noticed marks on the squirrel cage showing where the bars have become discolored, the clamping bolts made blue, etc? Have you noticed that these marks do not exist uniformly around the rotor, but are evenly spaced?

These marks of heating indicate that the motor has been stalled at some previous period and that the rotor has been over-heated. The marks have a pitch corresponding to the pitch of the poles in the stator. For an eight-pole motor, the marks occur at every 45 deg.; for a four-pole motor, they will be found to be spaced every 90 deg. When these signs are found, it is a sure indication that the motor has stopped and a heavy single-phase current has flowed through one set of windings, the rotor serving as the short-circuited secondary of a transformer, of which the stator represents the primary.

Where this condition occurs frequently, the stator soon begins to show signs of over-heating. Insulation chars, insulating compound melts and similar indications show that the stator is burning out. This cause of trouble can almost invariably be differentiated from heating due to overloads in a simple manner. With a three-phase overload, all loads in the stator alike char and burn out. Where the heating is due to single-phase operation only one set of coils overheat; or they are considerably worse than the others. In a delta-connected motor, one set of coils will need renewing; in a star-connected, two sets, since the current divides two ways with this type of winding.

The reason why sometimes a three-phase induction motor will start when only supplied with single-phase energy and sometimes not is on account of the wiring arrangement. Some motors are protected with two sets of fuses; some with only one set. One set is located in the main circuit and is heavy enough to carry a current well in excess of full-load motor current. The other set is located in the starting circuit of the motor and is so heavy that it will blow only on short circuit. Quite often the starting circuit is not fused at all.

With the first arrangement the running fuses blow, but the starting fuses remain intact because not in the running circuit. The motor slows down, but continues to run if the load is light enough. After being shut down and then started up, the motor starts and continues to run because the starting fuses are intact. If the fuses in the starting circuit blow, then a three-phase motor will not start because the single-phase field cannot exert continuous torque, but, instead, creates a pulsating torque which cannot be utilized by the three-phase winding.

Another sometimes puzzling condition is when a wound-rotor type of induction motor refuses to come up to speed and, instead, persists to exert sufficient torque at half speed. In cases of this kind, the writer always has found the trouble to be in the secondary or wound-rotor circuit. It may be in the windings, or in the controller by which the resistance in the rotor circuit is varied for different speeds or for starting under heavy load.

The reason why the motor runs at half speed is because a single instead of a three-phase circuit exists in the rotor through which a current of half the frequency of the supply circuit is induced. This current sets up a single-phase field in the rotor of half the normal frequency which is resolved into two opposing fields. The armature is traveling at half the speed of the primary field, the secondary current has a frequency half that of the primary so that one of these fields has a resultant speed equal to that of the primary field and travels in the same direction as the primary field. The other secondary field has a resultant speed of zero and therefore is ineffective.

The motor, therefore, locks at half speed and will not speed up. If load is put on the speed decreases, slip increases just as if it were running at normal speed, but with rapid drop in power factor. Look for an open circuit, therefore, whenever a wound-rotor type of induction motor locks at half speed. This same trouble used to be encountered occasionally with synchronous converters in the old days when starting them from alternating current before the pole pieces were equipped with grids.

# Fuses for Alternating Current Circuits

TYPES AND PRINCIPLES OF OPERATION. BY HOWARD D. MATTHEWS

WITH distribution circuits reaching out rapidly to rural communities, the power companies are completing the weaving of a web of wire over the entire nation. The success of this undertaking has been made possible not only by the development of generating apparatus, but also through the use of a wide variety of small devices. In a conspicuous place among these small devices stands the fuse, which, owing to its reliable and satisfactory operating characteristics, is found installed in large numbers.

It is the purpose of this article to present a summary covering the methods used in the various designs of fuses on the market, with no attempt to discuss the relative merits of the different designs or their particular performances.

There are perhaps but a few electrical devices on the market that are made in so many ways for accomplishing a certain purpose as the fuse. When a fuse ruptures in an electrical circuit, the arc formed may be considered somewhat of the nature of a fire, with the exception that the presence of the voltage adds to the hazard. The magnitude of the arc during such an occurrence may be reduced fundamentally by the following ways: (a) Remove the combustible material; (b) prevent admission of fresh air; (c) lower the temperature.

In the fuse, no combustible material is present in the element or should be surrounding it. The vaporizing of the melting element, due to the high temperature of the arc, causes an explosion magnified by the expansion of hot gases formed, and severe pressure and mechanical stresses result which may produce "r.p.m." to some of the parts, as some one has so aptly said. In any event, if the rupture is not immediate, a charring of the supports may occur which maintains the current flow until destruction of the device results. The designs in use indicate that advantage has been taken of such schemes that cause the arc to be broken quickly with the least amount of disturbance to the system, and with wear and tear on the device itself reduced to a minimum. A list of such schemes used in fuses on the market is as follows:

(a) Metal element exposed to the air for dissipating heat and reducing force of explosion.

(b) Metal element surrounded by non-combustible material for absorbing gases formed.

(c) Transfer of arc from fuse clips to horns allowing the arc to rise, and in lengthening, rupture.

(d) Metal element surrounded by liquid.

(e) Metal element confined giving high velocity to expelled gases rupturing the arc.

(f) Contacts separate after fuse ruptures with the aid of a mechanical device.

(g) Insertion of some non-conducting element across path of circuit after fuse melts.

Some fuses on the market are made up using a combination of two or more of the above schemes. Ordinarily one method is sufficient and has the advantage of simplicity and economy. The common names of these various designs are as follows:

(a) Link fuse (fuse element exposed to the air).

(b) Enclosed fuse (element surrounded by pellets).

(c) Oil fuse (element ruptures under oil).

(d) Chemical fuse (element ruptures under non-burning liquid).

(e) Expulsion fuse (element confined in tube opened at one end for discharge of gases at high velocity).

(f) Horn gap fuse.

(g) Capsule fuse (device contains a gas charged capsule which liberates gas when fuse melts, causing the arc to be blown out).

(h) Throttle fuse (insulating member supported by fuse element, cuts across the circuit when the element melts).

The various designs, to be successful, must function in a proper manner on a "slow burn" where the overload may just reach the blowing capacity of the melting element, or when a short circuit occurs near the source of power giving maximum stress. Ratings of the fuses indicate that normal overload protection may be obtained, or short circuit conditions only be provided for. The present-day tendency seems to be favoring the fuses selected for normal overload conditions.

Tests, indicating that the circuit may be opened in a small fraction of a second by the rupturing of a fuse, would show that sufficient rapidity exists to clear the line before the trouble spreads to the main circuits, causing the circuit breakers to open and thereby interrupt the service on other circuits.

The popular voltages range from 2300 to 6600 with most of the designs, while some of them have been installed on circuits up to 70,000 v. The recent report of the census bureau showing that the production of fuses and cutouts has increased between four and five times in 1919 over that in 1914, shows that the fuse is meeting a popular demand in a very satisfactory manner.

# Low Power Factor

IN A paper before the Power Transmission Section of the Institution of Civil Engineers, Reginald O. Kapp calls attention to the disadvantages from low power factor on a system. One is the extra capital investment required to supply a given power. If a plant would cost $75 per kw. of maximum demand for electrical equipment at a power factor of 1, this will become $92 per kw. with a power factor of 0.8, and the plant must carry this extra capital charge. At a load factor of 25 per cent, this will involve added cost of about 0.124 cents a kw.-hr.

Also, if station bus-bars are divided by reactances and power has to be supplied from one division to another, as is commonly done, low power factor will result in bad regulation; the alternators on the heavily loaded sections will furnish a large part of the wattless current, so that, while the generators are fully loaded, the turbines will be underloaded, resulting in high steam consumption.

In a system where step-up and step-do ... transformers are used, fluctuation of the voltage at the consumer's switch will be increased by low power factor. At 85 per cent factor, the variation may not be noticeable, while at 80 per cent factor the voltage variation may be 10 per cent, so that a customer with a bad factor may be a detriment to his neighbors as well as to the supply company.

At light load the power factor is considerably lower than at full load, resulting in alternators heavily loaded and turbines lightly loaded, with consequent high steam consumption and heavy percentage of loss on the transmission lines.

The most effective remedy for low power factor is applied on the consumer's premises, and it is to the interest of central stations to devise a scale of charges, based on power factor as well as power delivered, such that it will be to the customer's interest to install devices for bettering the power factor of his load. This involves the use of integrating rather than indicating meters, and one method is a small fixed charge per maximum kv.a. This has the disadvantage of penalizing low load factor and low power factor in the same charge, but has not prevented its considerable use.

A better way is to differentiate between load factor and power factor, one charge being based on the cost of readiness to serve of the non-electrical equipment (the load factor charge), while another is based on the cost of electrical equipment required (which is affected by power factor). This may be in the proportion of 2 cents per kw.-hr. plus 0.5 cent per kv.a.-hr., which at power factor of 1 would make the total charge 2.5 cents per kw.-hr., and with power factor of 0.8 would make it 2.624 cents per kw.-hr. One suggestion is that it is better to offer a bonus for a good power factor than to inflict a penalty for a bad one, basing the standard charge on a power factor of 0.8, with heavy penalty for a lower value and a bonus for each per cent above 0.8. The above data are taken from a report of the paper in London Engineering.

# Foreign Development in the Power Plant Field

INTENSITY LIMIT REGULATOR; ARGON LAMPS; VALVELESS PUMP; ELECTRICAL RESISTANCES. BY J. H. BLAKEY

PROTECTION of electrical installations against the effects of short-circuits has always been of primary importance. Reactance coils have been introduced to limit the value of the initial short-circuit current, and these are becoming general; but so far as the permanent short-circuit is concerned, the old methods are still in vogue and in a great many stations the automatic action of oil circuit-breakers is the only certain method of protecting the machines and the installation against the dangerous effects of the permanent short-circuit current. A break as rapid as possible was for long considered the best means of reducing to a minimum the damage caused by this current, which may attain a very high value in the case of several machines coupled in parallel.

It is, of course, not admissible to allow indiscriminately the operation of any one of the circuit-breakers between the alternator and the short-circuit, as a short-circuit produced, for example, in the secondary distribution system might cause the opening of the principal circuit-breakers, and consequently prevent the central continuing to supply the undamaged sections of the system. That is why devices have been tried which, while assuring rapid action, also make positive selection of the circuit-breakers to be operated so as to put out of commission only those sections in which the short-circuit has occurred. Among these, some require a very careful adjustment of the transformers; others, the employment of special construction cables or the establishment of complicated and costly auxiliary circuits. In addition, a number of these devices have the disadvantage of losing a part of their selective effect in case of violent short-circuits, and consequently to cause the opening of circuit-breakers which ought to remain closed in order to maintain the operation of the undamaged sections of the system. In this country there is a tendency to suppress the relays completely and to avoid automatic breaks, or at least to reduce them to a minimum. Alternators and installations are designed to support the short-circuit current, and when the total power of the machines in parallel necessitates too large a factor of safety, reactance coils are used to reduce the initial value of the short-circuit current. The use of these coils permits the reduction of the factor of safety without danger; but if they do not cause in normal service a too great fall of tension, they are without great effect upon the permanent short-circuit current, and therefore do not protect the installation against surchages and the dangerous heatings which may result from the prolonged action of this current.

This is why a method has been devised which permits leaving the alternator in short-circuit without danger; that is by reducing its excitation. If it is remembered that the number of calories produced are proportional to the square of the current intensity, the great advantage of this system will be recognized. The reduction of the excitation is done by hand, by means of a field rheostat, and presents no serious difficulty as long as there is in the central someone always ready to act in case of danger.

The situation is different in those installations in which the use of automatic voltage regulators makes unnecessary a part of the personnel. However, the voltage regulator, in increasing the excitation voltage when the e.m.f. of the alternator falls on account of short-circuit, augments the power of the short-circuit current and thus renders quick action so much the more necessary, especially when it is a question of regulators which in case of short-circuit establish an excitation voltage surpassing by 30 to 40 per cent the normal excitation at full load. The danger of surcharges and dangerous heating is then such that it is necessary to furnish these appliances with devices which in case of short-circuit put the regulator out of service, thus establishing an excitation inferior to that while running idle. These devices have brought the desired result, but they have the disadvantage of leaving the regulators out of service when the short-circuit has disappeared; it is then necessary to re-establish normal voltage by hand and to replace the regulator in service. The Societe Brown, Boverie et Cie. has devised an appliance which re-establishes the normal excitation automatically at the moment of the disappearance of the short-circuit, and which has proved itself satisfactory during a number of years. It is described in La Revue B.B.C. for August last. This appliance (Fig. 1)

scarcely differs in construction from the B.B.C. rapid action voltage regulator with silver plate contact sectors. The turning system, the sectors and the contact segments in an arc of a circle, have been retained. The deadening arrangement has been suppressed in order to bring about as rapid and energetic action as possible. For three-phase current installations the apparatus is branched (Fig. 2) upon two current transformers of which the secondary circuits are connected in parallel. As a limit-regulator is branched upon two phases, it functions surely whether in case of a short-circuit between any two phases or of a three-phase short-circuit.

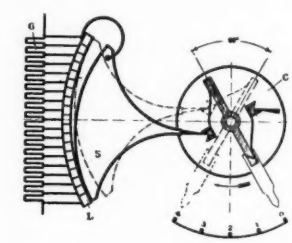
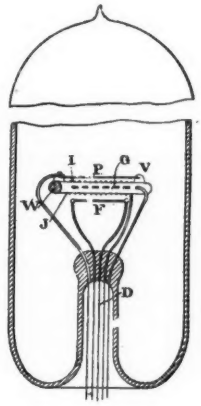


FIG 1



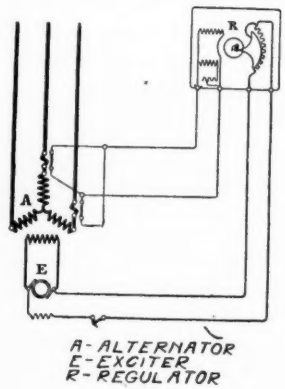




FIG. 2

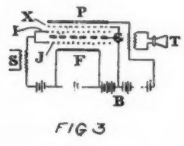



FIG 3

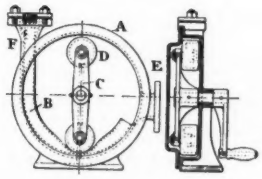



FIG. 4

FIG. 1. BROWN BOVERIE INTENSITY LIMIT REGULATOR
FIG. 2. CONNECTIONS FOR INTENSITY LIMIT REGULATOR
FIG. 3. LAMP WITH AUTOMATIC VOLTAGE COMPENSATION
FIG. 4. BENNET VALVELESS PUMP

The turning system is similar to that of the tension regulator; the electro-magnetic rotation couple is in opposition to that of a spring. When the spring couple is strongest, the movable part of the appliance is pushed over to the position to the right, and the index is then over the zero on the scale. As soon as the current exceeds the value for which the apparatus has been adjusted, the electro-magnetic couple overcomes that of the spring and the movable part is displaced toward the left. The regulation resistances are contained in the part behind the regulator and connected to the contact segments.

When the movable part is in the zero position, the resistances are short-circuited. At position 4, all the resistances are inserted by the movement of the sector upon the segments L, and consequently the minimum value of excitation is established. When the short-circuit disappears, the movable part returns automatically to the position O, the regulating resistances are short-circuited and the normal conditions of service re-established. The value of the current for which the two couples are in equilibrium at the point 4 exceeds by 15 per cent that corresponding to the position O. By means of an adjustment contact at the lower part of the apparatus, one can regulate at will between 100 and 200 per cent of the normal current of the alternator, the value of the current at which the movable part leaves its zero position.

## A New Argon Lamp

The Allgemeine Electricitats Gesellschaft of Berlin has obtained for such a lamp a French patent No. 513,301, published Feb. 12, 1921.

It has been recognized for a long time that the smallest trace of water vapor in the argon provokes a premature disintegration of the filament and a very rapid blackening of the glass of the lamp; but if the argon is absolutely pure, it allows the easy formation of arcs, and this difficulty is such that a mixture of argon and nitrogen is preferred to an atmosphere of pure argon. Usually the nitrogen is used in the proportion of about 20 per cent.

As, however, pure argon, when it can be obtained perfectly dry, possesses marked advantages, the inventor has attempted to reduce to a minimum the proportion of nitrogen in the mixture, and even to eliminate, if possible, by using traces of electro-negative gases such as chlorine, or other halogens, pure oxygen, sulphur, selenium, tellurium or phosphorus. By using phosphorus, it is found that all danger of arc formation is avoided, even if the atmosphere is practically pure argon without appreciable trace of nitrogen. The functioning of the lamp has been very satisfactory and is more economical by about 0.1 w. per candle than the lamps with an atmosphere of argon and nitrogen. It is found practical to apply on the base of the lamp, or upon some other interior part, a small quantity of red phosphorus; when the lamp burns a sufficient amount of vapor is disengaged. A suitable amount of phosphorus can also be vaporized in the lamp before closing it with the torch.

## A Lamp with Automatic Voltage Compensation

The Siemens, Halske Aktien Gesellschaft has obtained a French patent, No. 505,897, published Aug. 9, 1921, for a lamp of this kind.

The filament F is supported by two metallic wires of which the base is soldered into the glass composing the foot of the lamp. The plate P is fixed upon the same support as the grills G, I and J, which are the regulating elements. This support W is a glass rod bent in form of a U, in a horizontal position. Between its branches is arranged the grill G, formed of zigzag wires of which each one of the turns is soldered to the inside of the branches of the U. Outside of these branches are enrolled the auxiliary grills I and J, composed of fine wire, the extremities being soldered into the U. The plate P is fixed upon the U by means of projections on the glass which hold each of its four corners. As shown in the lower figure, the auxiliary grills I and J are coupled in parallel, and they are brought to a

feeble negative voltage in relation to the filament F. The grill G is connected to an intermediary point of the battery B, which communicates to it a positive tension superior to that which its position in the electronic field assigns to it. This arrangement has the effect of reducing sensibly the reaction which the variation of the voltage of the anode exercises upon the phenomena occurring within the lamp. The mounting indicates how these phenomena could be reduced still more by interpolating between the anode and the auxiliary grill nearest to I, another grill X kept at a constant positive tension.

### The Impregnation of Wooden Posts for Electric Lines

In Europe the posts for electric lines are nearly always of pine, and their duration seldom exceeds 5 yr. Thorough impregnation has been found to extend this period to as much as 20 yr. According to the Elektrische Kraftsberiebe und Bahnen, of March 21, impregnation by means of chloride of zinc gives a mean duration of 12 yr.; the Boucherie process by sulphate of copper, more than 14 yr.; impregnation by bichloride of mercury, more than 16 yr.; by tar oil, about 23 yr. These figures correspond to a complete impregnation of from 12 to 18 lb. of the chemical per cubic foot of wood. As regards the effect upon destructive fungi, the efficiency of bichloride of mercury being represented by 100, sodium fluoride has a value 25, sulphate of copper and chloride of zinc, 3 to 5. The best results are obtained with a mixture composed of 0.06 lb. bichloride of mercury, 0.6 lb. chloride of zinc, 0.6 lb. sulphate of copper and 3.5 lb. of tar oil, per cubic foot of wood. If these proportions are diminished the efficiency of the impregnation is considerably decreased. At the present state of the market, the annual cost would be at a minimum when the price of the unimpregnated post is one-third of its price impregnated.

### A Pump Without Valves

The English journal Engineering of June 24 gives a description of a pump without valves, constructed by C. G. S. Bennet. As will be seen by the figure it consists simply of a circular casting with an opening on one side, into which is inserted a length of rubber hose. The revolution of the arm C on which are fixed the rollers D first drives the air out of the hose, producing a suction which is said to raise the water for a considerable height. The joint F is so designed that a new length of hose can be attached in a very few minutes when the one in use is worn out.

### Composition for Electrical Resistances

The Kummlet et Matter Cie., resident in Switzerland, has obtained for such resistances an English patent, No. 153,602, published Jan. 19, 1921. The coefficient of temperature of these resistances is negative. The material is composed of carburet of silicon, carbonate of calcium, graphite and a metallic oxide. These components are finely pulverized, mixed and molded to the form desired, and then heated in sand to agglomerate them perfectly. As an example of the proportion in which these elements may be employed, the patent cites the following: 10 parts carburet of silicon, 4 parts carbonate of calcium, 4 parts graphite and 1 part oxide of iron.

### English Experiment Station for Testing Combustibles

This experiment station has been open to the public for only a short time, though it has been in operation for a number of years. It is located at East Greenwich, near London. It employs a number of chemists and engineers, who work together in order that the discoveries and observations of each may be co-ordinated in such a way as to bring about practical results. The Engineer of July 8 describes the installation and the appliances in use and notes that none of the instruments commonly used in industry are employed at the station. Neither those of Orsat nor those of Hempel are considered of sufficient precision for the experiments undertaken, and more modern instruments, such as those of Bone, Wheeler and Haldane, have taken their place.

The station contains a plant for the liquefaction of air, for use in the fractional distillation at low temperature of certain constituents of combustible gases, or of the residues of combustion. Among the experiments being made are tests of various peats, lignites and marine algae, in view of their drying, of the extraction of gases and the manufacture of a special coke. Not only has the station tested all kinds of boiler fuels, but it is working also on experiments leading to the selection of those liquid combustibles best suited for Diesel and semi-Diesel motors.

---

# Air Tank Explosion

By R. L. Hemingway

A rather unusual explosion of an air tank recently occurred in San Francisco, unusual because of the freedom from damage to property, other than the tank itself, and the absence of personal injury. The freedom from these two usual concomitants of an explosion of this kind is occasioned by the extraordinary nature of the rupture that occurred in the tank.

On glancing at the illustration, it will be noted that the bottom head (the tank stood vertical) was completely torn out from the shell, with the exception of a very small piece that was left attached to the head seam. The top head tore through the middle, shearing all the rivets around one-half of the tank circumference, the other half of the head remaining attached to the shell.

The tank in question was originally an old hand-riveted iron boiler drum and was probably well over 30 yr. of age. Its external condition, and indeed its internal condition, gave no evidence of the defective condition of the material. The principal dimensions of the tank are as follows: Diameter, 30 in.; shell plate, iron, ¼ in.; longitudinal joint single riveted lap, ⅝ in.; iron rivets in $^{11}/_{16}$-in. holes; pitch 2 in. The heads were ⅜ in. thick, and flat, with a handhole in the center, and were supported by six ⅞-in. through rods with nuts, inside and out, but no washers.

One side of the drum carried two 6-in. cast-iron nozzles that formerly connected to nozzles on the boiler shell. On the opposite side was a 4-in. outlet, formerly used as the main steam outlet of the boiler. One of the 6-in. nozzles was covered by a $^{3}/_{16}$-in. blind flange, which

under a pressure of not to exceed 90 lb. showed considerable distortion.

The extraordinary part of this explosion is that both heads let go simultaneously and to this fact alone can be attributed the absence of damage or personal injury, because the release of pressure taking place in opposite directions served to counteract the sudden dissipation of the pent up force. In addition to both heads letting go, all six of the through rods were broken.

Examination of the fractures in the shell and heads reveals the fact that the material, owing to the fatigue produced by age and service, had assumed a crystalline structure strongly resembling that of a good grade of cast iron. The initial rupture in both cases of the heads must have taken place a long time ago, the surface of the fracture from the handhole to the brace hole on both sides is dull and rusted. From the brace hole to the knuckle of the flange the fracture is brightly crystalline.

Some of these laminations that existed in the material were so deeply and widely separated that a steel rule ½ in. wide and 0.019 in. thick could be entered to a depth of approximately ⅜ in.

The tank had never been inspected by the Industrial Accident Commission or by any other certified inspector and gave no warning of any description before letting go. It is extremely doubtful whether or not an inspection would have revealed the cracks that have existed for a number of years in each head. The fact that the through braces were practically inaccessible, excepting through a handhole, would have also probably prevented an inspector detecting that they were broken.

Consequently, the only protection that the user of a tank of this description has, even though subject to regular inspection, is the use of a steadily increasing factor of safety based upon age. Thus, basing the calculation for the bursting pressure of the shell on the data given above and with an efficiency of 62.69 per cent for the joint, we find that 470 lb. per sq. in. is the theoretical point of rupture, which, with a factor of safety of 6, gives a working pressure of 78 lb. The probabilities are that this drum, when used on a boiler, operated for many years at not less than 100 lb., and consequently even at a factor of safety of 5, which would give 94 lb., has been considerably overstrained.

HALF OF UPTURNED TOP HEAD ATTACHED TO SHELL AND FRAGMENTS THAT WERE TORN OFF

It is hoped that this explosion may serve as an object lesson to other users of old equipment who may desire to keep up with the pace of modern times.—California Safety News.

# Trouble Hunting

By John Pierce

ABOUT the time that I had fixed up the cutouts and the circuit breakers, I found a queer action taking place with the big main generator. This was a "Western Electric" 125-v. 3000-amp. direct-current generator running at 120 revolutions, direct connected to a compound tandem Nordberg engine. This machine had been, up to this time, running quietly and sweetly, giving no trouble in any way, and what followed was to me a strange thing, and even now I can not understand what it was. Beginning about three in the afternoon of one day, a number of the brushes began to "glow." These brushes had been on the machine for a long time and had given satisfaction. In fact, they were still giving satisfaction except that they had got worn down quite short; however, as I said, they began to glow and got red hot right now! The chief electrician sent for me and I told him I thought perhaps he had better remove the brushes that were heating and put on new ones. He did this and the trouble apparently disappeared.

That night I made my usual round at 11 o'clock and found the machine going very nicely. I tested each one of the 64 brushes for tension and found them all about right. Then I went home and went to bed. My house was so situated that I could hear the beat of the engines, and the exhaust or discharge of the air pump on the condensing plant. I had not yet gone to sleep when I heard the other engine, which was a high-speed, direct connected to the second, or reserve generator, cut in and the other generator cut out. Before I could get off my night gown—yes, laugh, gol ding you, but if my friend Theodore Roosevelt wore one, why shouldn't I?—and found my clothes—the second, or reserve generator being somewhat smaller than the number one, all the yard and colony house circuits were left out when this engineer was working; therefore I was in the dark, and if any of you guys ever tried to put on your B. V. D.'s in a hurry in the dark you will know just what I was undergoing at this time. I finally got them on, but discovered that I'd got my arms in the legs and my legs in the place where the arms ought to go. I jerked on a bathrobe and a pair of house slippers and made a run for the seat of trouble.

It was a short cut to go over the narrow wall of the little "Italian city"—see back issues to learn what this was—and at the point just before the water went over the diving board, the connection was spanned by a 6-in. plank. It was 5 ft. down to the water and I fell all the way, for some sucker had removed the plank. The water was 8 ft. deep and I touched bottom. Now, let

me explain to you that the side walls of all these little canals were built sloping, the concrete was covered with slime, that the water was 8 ft. deep in most places and 9 in some, that the walls stuck out of the water some 4 to 5 ft., and you will see that Uncle John was in a hell of a fix. I sure thought I was a goner. I'd already got the bath robe off but I was afraid to try the B. V. D.'s, so I left them on. I swam around and around until I was sure I'd never get out, and had begun to think of the grief and burdens of those I was going to leave behind, and had almost got to the point of shedding tears over myself when I hit an old pipe that had formerly been a part of a spray system. I managed to climb up on this and then straddled it and cooned my way ashore, but still on the wrong side of the canal. I said I'd cross her or die trying. I crossed all right, but I got down on my hands and knees and crawled over after finding and replacing the plank.

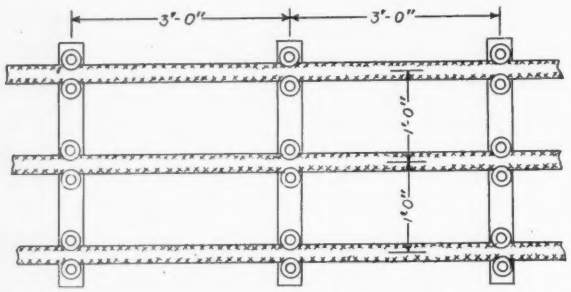



FIG. 1. METHOD OF CARRYING CABLES ALONG THE WALL

I finished my trip quickly and found the generator looking like a wreck. Every brush holder was melted and only one extra one on the place. The brushes were ruined and it looked at first as if the commutator might be also. I sent for the entire crew of electricians, the brass molder, the patternmaker, and a couple of machinists, ordered them to come on the run, and in the course of an hour had them all at hand. I started the patternmaker in on the patterns for new brush holders, and taking some of the undamaged parts of the burned holders, put the molder to work to get out castings of brass from them. The machinist I had to make springs and fittings. The electricians were put to work cutting new fibers for the quadrant and doing various things about the machine. The reason for all this haste was that a part of the plant would have to shut down until the generator was on the line again, the smaller one not being capable of handling all the load. Everyone knows what it means in an overloaded business running 24 hr. a day, every day in the year, to have any one department slow up or quit. It will be readily seen, therefore, why it behooved me to get real busy and to get busy quickly.

By morning we had the thing looking a little better and we began to feel hopeful. About 10 o'clock the brass foundry turned out the brasses which we began at once to dress into shape. The patternmaker had finished his patterns and we started in on the molding of the other pieces, and at midnight had all the castings out of the foundry, and at noon next day they were finished and on the machine. We also had nearly a full new set extra, having cast a great many more of each than we needed.

In the meantime we had been testing the machines and the leads to the board, but could find no cause for the occurrence. We were sure it could be nothing on the lines outside the house, for the other machine showed no signs at all of anything but perfect condition. Still, to make absolutely sure, we went over every inch of our lines, examining everything carefully to see that there had been no shorts, grounds, crosses, or anything else that could have blown us up. There was absolutely not a sign. We were without brushes for the machine, and I had taken other and larger brushes and cut them down until they made a good fit, and put them in service. When we started up and threw the load back on this machine, she ran as prettily as any machine ever ran, and we all went home, tired but contented.

We failed to knock wood, though, and after running about 18 hr. a brush began to glow. Changing it helped, but soon another brush did the same thing and then another. In the first case, before the machine went to the bad, I had begun to think that perhaps there might have been some sort of crystallization in the holders that offered too much resistance to the current; but with the new holders, all good new brass, I could hardly conceive this to be the trouble. Changing and dressing the brushes kept one of the electricians busy day and night, for no sooner would one be replaced than another would start in. You may well believe that Uncle John was some worried.

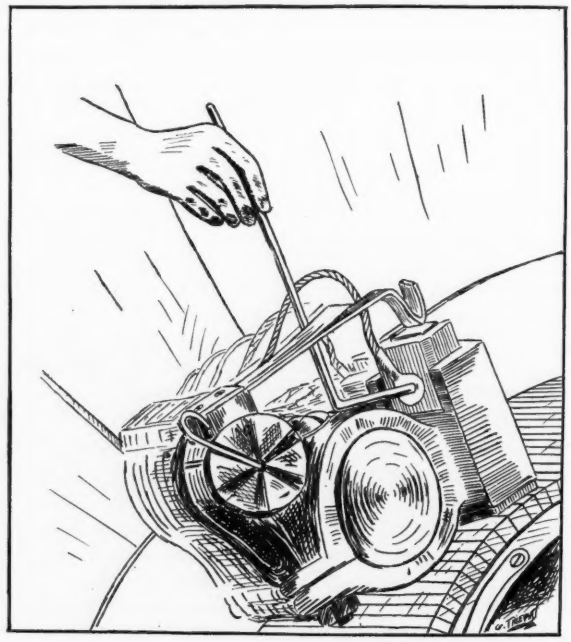


FIG. 2. I STUCK MY COPPER WIRE HOOK DOWN OVER THE SCREW HOLDING THE PIGTAIL

About this time, one of the company's expert electrical engineers came along. I told him my troubles and together we went over and looked at the old girl. He said he could not say "offhand" what ailed her, but that he was much interested and would try to study her out. The next day he came to me and said that the lead wires running from the machine to the board, underground, through some 200 ft. of conduit—for conduit we have a 6-in. pipe—was shorted and should be

worked on. I asked him how he knew and he said that it could not be anything else. So I had my men bring a roll of wire, and mind you this cable was 1½-in. flexible copper, exclusive of the insulation, and work that night, putting up a neat set of wooden rams, or carriers, running up and down the wall, and carrying the cables, see Fig. 1, with each set of knobs only 3 ft. from its neighbor.

The lines were spaced 1 ft. apart, and being a three-wire machine, it looked very neat. We used, after the cables were in place and all lined up in first class shape, some thousands of feet of 2-in. linen tape—this was just plain white tape similar to bandages used by the medical fraternity—and by wrapping it neatly and tightly made a very fine finish for our cables. It was then painted over with two coats of black enamel, and the wood work painted with white enamel, which gave me a very attractive set of lines. After this was done, we "jumped" from the generator to the lines and from the board to the other end and disconnected the old leads from the machine, letting the "jumpers" carry the current until the ends of the new cable could be secured to their proper terminals. The old cables were then pulled from the conduit and examined. They were in fine shape and showed no signs of wear. I was very glad, however, to have made the change, for the conduit had its beginning and ending outside the building, and I was always afraid some peon would leave the manhole open and the conduit would become flooded.

The generator showed no signs of having been cured, and kept acting as bad as before. I will say, at this point, that the brushes were all fitted with "pig tails." The expert then decided that the resistance, bolted on the machine, was in bad shape and said it *must be that;* so I hunted out a marble slab, drilled the holes and placed my slab on the *outside* of the frame where it could be readily gotten at. When everything was ready, we changed over the machines, removed the resistance from the inside of the frame and mounted it on the slab of marble. I then knocked out the old wooden wedges and repeaters and fitted new ones, and started up again. Still no better results; so the expert said frankly that it was beyond him, and that he'd give it up.

In the meantime, while we had wired several places for new brushes, we were using up all the other various sized brushes in stock, cutting down the large ones and building up, by doubling, the small ones. Finally, I though that perhaps some of these brushes must be harder than the others and so, the softer ones offering less resistance, they were taking it onto themselves to carry the greater part of the load; so I hunted out and fitted a full new set, all the same resistance, and made for the same machine. These I cut down to the proper sizes, fitted them up with a fine new set of "pig tails" and put them all on. But the devil still persisted. It seemed as if the machine was possessed of evil spirits, or that it had a "joush." I then tried to remedy it by underslotting. The commutator was in the best possible condition; had no high spots, brushes did not chatter, and the color was a rich brown, one that I have always tried to secure on direct-current generators and motors, and I simply underslotted because I did not know what else to do. I was frankly "up against it" and I saw my reputation going over the hill and fast disappearing. One thing that was a great help to me, though, was that the aforesaid electrical expert stood high in the councils of the "higher up" and he frankly stated that there seemed to be some peculiar unknown conditions prevailing and that I was doing all anyone could do—that is, I was "trying" and "trying damned hard" to find and remove the cause. I sure felt as grateful to this fellow as any human being can feel toward his fellow man, believe me. After underslotting and starting up again, I could see no apparent change in conditions and grew desperate. I shifted the quadrant forward, and I shifted her back, and finally I set her in her original position. I was about to give it up and ask for a new armature complete with commutator when I noticed another brush starting up. I had a wire in my hand that I'd fashioned into the shape of a packing hook, having been using it to clean out between some of the ends of the commutator bars.

There was one peculiar thing that I was beginning to take notice of, which was that the upper, or outer, end of the brush always got hot first and not the end resting on the commutator. In starting to pull out this brush, I had a little trouble in getting the spring loose and burned my fingers; but as it was rapidly getting hotter and hotter, I stuck my copper wire hook down over the screw holding the "pig tail" to the brush and pried on it, resting the wire hook over the brush carrier bar. Imagine my surprise to note that the brush at once began to get less bright, and in a moment it had ceased to show red. I did, fortunately, have sense enough to hold my wire where it was while I studied the matter over.

I began to see what I thought was a great light, and leaving the wire where it was, only stopping long enough to make it more secure, I chased over to the electrical department and got me a lot of new "pig tails" of the heaviest type we had. Hastening back with these and the chief electrician, we hurriedly began putting them on the brushes, removing the brush from the machine and after securely fastening pig tail number two, putting them back again. In the course of an hour, we had the entire 6 by 4 brushes carrying two tails where only one had sprouted before.

To this day, the machine has never given any more trouble, and those same brushes with their double tails are still on it. The question in my mind still remains, however, for it was a very frequent thing with me in the past to *cut off* the tails on new brushes when putting them onto a machine, and I can't figure out why this cured the old girl—though cure it, she did—what there could have been in the holders that they would not carry the current was, and is, beyond me. So far, though I've explained this to many electrical men, I've found no satisfactory explanation.

---

WESTINGHOUSE ELECTRIC & MANUFACTURING CO. has established an oil testing service to which operators can mail samples of insulating oil for test. It provides a thoroughly dry bottle, a safe mailing container, which when received at the works allows careful testing by experienced men and a prompt report of test results. This fills the needs of many power plant operators who have no good method of telling whether or not their transformer oil is in perfect condition. Instructions cover the taking of the sample and its proper preparation for mailing.

# Limitations of Silent Chain Drives*

By F. G. Anderson†

CHAIN used on wheels or sprockets for power transmission is no doubt one of the oldest of mechanical contrivances, but the use of the "silent" chain for large and high-speed power transmission is hardly a quarter of a century old. For some years, this drive was known to the general public as a means of transmission to be used only under conditions decidedly unfavorable to belts, gears or ropes. While such is now sometimes the reason for chain installations, the silent chain drive has gradually won on its merits until it is now generally considered by competent engineers as a standard drive for practically all of the ordinary power transmissions between parallel shafts.

There are definite reasons why silent chain drives have reached this place in the industrial world, and they are the same as first caused their use on the unusual and specially difficult drives 25 yr. ago. Briefly, they are:

First, reliability.

Second, positive speed ratio with flexibility of operation.

Third, possible short center distances.

Fourth, minimum attention required.

Fifth, high efficiency.

Sixth, quiet running.

When these features of silent chain drives were definitely established, it became advisable to provide conditions of installation favorable to successful chain drives. Hence we find that whole shops are laid out for short center distances instead of for long belt centers, motor speeds are selected to give proper speed ratios, etc., to obtain the reliability, flexibility and high efficiency of these drives.

As to the reliability, it may be stated that the breakdown of silent chain drives is not sudden unless a crowbar or similar husky object gets into the drive. If the drive is abused by overloading or overspeeding, the breaking down is gradual and will always give ample warning of final giving out to allow time for necessary repairs, or possibly a new drive of better design. This warning is given in the case of overloading or overspeeding by the increasing chain pitch. The wear in the chain—or the increase in chain pitch is manifested by the chain riding higher and higher on the sprocket teeth. This should, of course, be observed occasionally and the chain should be repinned with oversized pins before it rides over the sprocket teeth. Repinning with oversize pins compensates for the wear in the links and brings the chain back to normal pitch. If this is done before it rides over the sprocket teeth, the sprockets are saved and will be good for probably three chains. The wear on the sprocket teeth is negligible, as the chain pressure is distributed over the large number of teeth engaged.

The name "silent" has grown up about this product because of its quietness and also to differentiate it from the roller type of chain. Of course it is not silent, but it is quiet. There are noisy drives, but the noise—or comparative quiet—is purely a matter of design.

Sometimes we stretch the limits when it seems that nothing else will do, or when a customer is willing to sacrifice quietness for other desirable features, and then we often get the noisy drives. Noise is usually the result of overspeeding. There are pretty definite maximum rotative speeds for each pitch of chain. When these are exceeded, the drives are noisy.

There is also a limit to the width of a strand of chain. Good practice would make the width not less than 1.5 multiplied by the pitch and not more than 10 multiplied by the pitch, although these limits are sometimes exceeded with entire success.

Chain drives have been made to transmit as much as 5000 hp. and to transmit small power as high as 3000 r.p.m. Naturally the larger power drives are of comparatively low rotative speeds using large pitch and the high-speed drives of lower power using the smallest pitch.

Chain velocity may be as high as 5000 ft. per min. It is not the velocity that bothers—it is the rotative speed. The wear occurs on the small sprocket. Five thousand feet on a small sprocket, say 15 to 40 teeth, is utterly prohibitive, but a large sprocket, say from 50 to 100 teeth, might be permissible.

As to speed ratio, good practice holds to about 6:1 as maximum for large powers and 8:1 maximum for small power drives. The limitation on this is merely a matter of tooth contact—the more sprocket teeth in contact with the chain the less is the allowable wear on the joint before the chain climbs over the top of the sprocket teeth.

For speed ratios greater than the foregoing, slower speed motors or double reduction drives are usually recommended. Of course the double reduction is often undesirable, but there are a large number of them used.

Some engineers have thought that chain drives should be used only on steady loads, but they are successfully applied to practically every kind of load. For a rhythmic uneven load such as a compressor, a spring compensating sprocket may be used if the flywheel does not provide sufficiently uniform rotation to prevent a whipping action of the chain. These sprockets have been used in sizes up to 300 hp. with entire success. It is better, however, and oftentimes cheaper, to provide sufficient flywheel.

For occasional shock loads, the shearing pin sprocket is used. Here the pins connecting the rim to the hub shear on predetermined load and the rim spins around on the hub, thus protecting not only the chain but the driver (engine or motor) and the driven unit. New pins are quickly and easily inserted and the drive again started. Many expensive shutdowns have been prevented by these sprockets when machines become clogged.

Reversing drives are successfully handled by silent chain.

Some drives have lasted 16 yr. on practically daily service. This, of course, is the unusual, and we consider that the average life of a properly designed drive working under reasonably favorable conditions is from 15,000

*Abstract of paper presented at the Exposition of Chemical Industries.

†Manager of New York office of Morse Chain Co.

to 18,000 hr., or 5 to 6 yr. of 10-hr. days and 300 days per year. By life here we mean life without repairs.

Maintenance cost is that of new pins for the chain. This amounts to approximately 20 per cent of the cost of the new chain, which is low inasmuch as the life of the repinned chain should be at least 75 per cent of that of the new chain.

Sprockets usually outlast three chains or one chain twice repaired. The sprocket wear is small because each tooth engaged with the chain takes its proportional share of the chain pull, therefore the single sprocket tooth bearing pressure is very low on large sprockets which are cast iron and on small sprockets which are steel casehardened.

Sprockets under 29 teeth are made of medium carbon steel and casehardened. Large sprockets are made of semi steel or cast iron.

Chain links are made of special alloy steel and heat treated to give required toughness. The pins are high nickel steel and casehardened.

### Lubrication

The round pin chains require oil lubrication, whereas the rocker joint chain is better lubricated with grease. Oil lubrication is best accomplished by running chain in a bath of oil which requires an oil-tight case. Grease lubrication requires no guard except to catch that which may be thrown off at the sprockets.

There are limitations to the successful application of chain drive, but the proper application covers a wide field and is ever increasing in amount.

The design of these drives is still a specialty and all your power transmission problems should be submitted to chain engineers.

# Power Plant Troubles

Overcoming Trap Difficulties by Special Piping and Use of Swing Check Valves. By H. A. Jahnke

FREQUENTLY we have trouble with some apparatus in the plant, the cause of which cannot be found until accidentally located. This happened to me a short time ago. I use tilting straps for boiler feeding. I had noticed for some time that one of the traps was not furnishing as much water to the boiler as it did before with the water supply valve wide open. I had done everything I knew of to find the cause of the trouble, but failed until I found it accidentally.

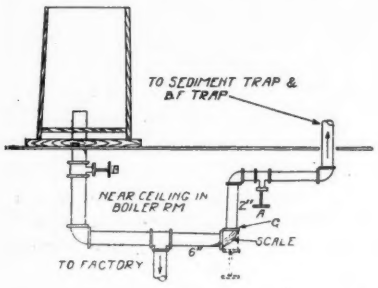


FIG. 1

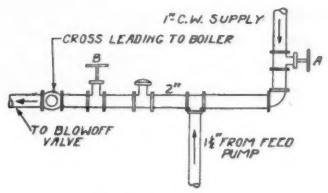


FIG. 2

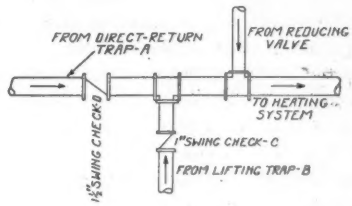


FIG. 3

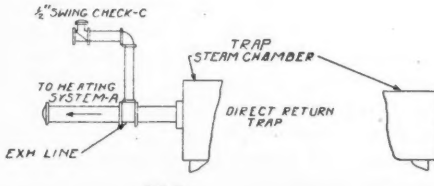


FIG. 4

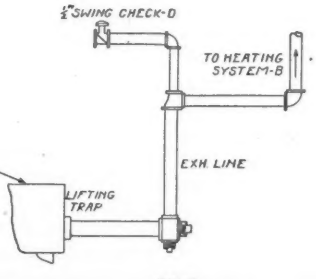


FIG. 5

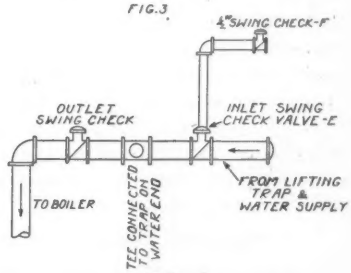

4" SWING CHECK-F
OUTLET SWING CHECK
INLET SWING CHECK VALVE-E
TO BOILER
TEE CONNECTED TO TRAP ON WATER END
FROM LIFTING TRAP & WATER SUPPLY
FIG. 6

FIG. 1. PIPING TO TRAP WHICH SCALED UP. FIG. 2. BOILER FEED PIPING. FIG. 3. EXHAUST PIPING OF RETURN TRAP. FIG. 4. REVISED RETURN TRAP PIPING. FIG. 5. CHECK VALVE IN TRAP EXHAUST TO PREVENT STEAM BINDING. FIG. 6. PIPING TO PREVENT AIR BINDING OF TRAP

It will be noticed in Fig. 1 that the trap receives the water from a tank which is located in the same room above the boilers that the trap is; it also will be noticed that the pipe furnishing water to the trap and factory is connected into the bottom of the tank, then runs along near the boiler room ceiling. There are a number of turns in the 2-in. pipe before it reaches the trap made necessary by some obstruction being in the way. It was necessary to disconnect the valve A in the line leading to the trap, as it had to be renewed, due to being worn so it could not be closed tight. When the pipe was disconnected and valve removed, I opened the valve B near the tank to give the pipe a cleaning out, when, to my surprise, but little water came out of the pipe leading to the trap, then the pipe next to the elbow C was taken out, when I found that the elbow and vertical piece of pipe was nearly clogged up with scale from the trap, as illustrated. When this scale was removed and all connections were made up again, the trap furnished as much water as before.

In this arrangement of piping, a sediment trap was placed near the boiler feed trap to prevent any scale or other foreign matter from going into the trap and nobody ever thought that the pipe would clog up with scale at the point it did.

To prevent this trouble from occurring again, the elbow C was removed and a tee put in its place, then

a 4-in. long nipple and cap was placed in the lower opening of the tee, in which the loose scale could collect, which was removed by taking off the cap whenever necessary.

### Why the Boiler Filled with Water

An engineer complained that his boiler would be completely filled with water on Monday mornings after he left it on Saturday nights with about 2½ gages. This occurred a number of times and the engineer could not understand why the boiler behaved in this manner, for he was sure that none of the valves that would admit water into the boiler leaked, as the water in the boiler was not necessary during the night in a week's run; hence, why did the boiler fill up with water between Saturday night and Monday morning?

My advice was asked regarding the matter. After making an investigation of the feed pipes to the boiler, layout of which is shown in Fig. 2, it will be noticed that the cold water line from the city main is connected into the feed line. This line is used only when refilling the boiler after cleaning or whenever the water is low in the boiler, mornings, or the fire is banked during the night. It was my idea that the valve A in the cold water line leaked. To make sure of this, the valve B was closed after shutting down the feed pump, then a union was disconnected between the pump and tee, when we found that the valve A leaked badly and also valve B leaked a little, but not enough to close the check valve tight.

After this discovery, it was an easy matter to tell why the boiler filled with water. As there was no fire under the boiler from Saturday night until Monday morning, there perhaps was but little pressure in the boiler on Sunday morning and as the pressure in the city main at this point is from 50 to 60 lb., the water started to leak through the two valves into the boiler as soon as the pressure in the boiler was below that in the city main and kept on running into the boiler until this was completely filled. In this way, much water was wasted. It also took much more coal on Monday morning to raise the steam pressure, as the water in the boiler had cooled off considerably by the cold water running into the boiler, all due to carelessness on the part of the engineer for not making much of an attempt to locate the trouble long before it was found. A new valve was placed in the cold water line and to make doubly sure this trouble would not occur again, an asbestos packed cock was placed next to the valve on the boiler pressure side.

### Overcoming Some Troubles with Traps

Where tilting traps are in use for boiler feeding and returning the water of condensation from the heating system to the boiler, where the vent or exhaust steam from these traps is discharged into the atmosphere, there is very little trouble with the pressure being released immediately after the trap tank drops into the filling position unless the steam valve is not adjusted correctly or leaks badly; in that case the pressure remains for some time before it goes below that of the water pressure. This may prevent the trap tank from filling as quickly as it should, hence the trap will act more slowly than otherwise and the boiler will not receive sufficient water, or if the trap is connected to the receiver of a heating system, the trap may not operate often enough to keep the system clear of condensation, when there is trouble.

Then again where the trap's exhaust discharges into a low-pressure heating system or into the condensate receiver as frequently is done in some plants, there frequently is trouble, due to the fact that the pressure in the trap tank is not released as quickly as it should be so that the water from the receiver or whatever point it may come from will run into the trap tank.

I have had my share of troubles with tilting traps of the different types that discharged the exhaust into a heating system carrying about 3 to 4 lb. of pressure. I have done much experimenting in piping up the exhaust lines in different ways in order to overcome the trouble of the pressure running longer in the trap tank than it should.

Figure 3 shows the layout of the vent or exhaust pipes of a direct return trap used for boiler feeding and of a lifting trap which forces the condensation from the heating system into the direct return trap. It will be noticed in Fig. 3 that the exhaust pipe from the two traps are connected into the heating system on the low-pressure side of the reducing valve. In each line from both traps where they connect into the heating system there is a swing check valve near the main line as at C, D. This is to prevent any pressure from backing up from the heating system into the trap tank to prevent this from filling with water but at times these check valves would not close tight or leak when the pressure in the tank of the direct return trap would not go below that of the water pressure from the supply tank, hence the tank would not fill.

To overcome this trouble I placed a tee in the exhaust pipe near the direct return trap as shown in Fig. 4, then placed a ½-in. swing check valve as shown at C. In this way should there remain any back pressure in the trap tank after the trap has discharged the exhaust due to the check valve near the heating system not closing tight and as this pressure is not sufficient to keep the ½-in. check valve C tight this would automatically release the pressure in the trap tank enough to get below that of the water pressure, hence the trap would fill with water.

I overcame this same difficulty with the lifting trap by placing a ½-in. swing check valve in the exhaust line as shown in Fig. 5 at D. I have found that the water inlet swing check valve, Fig. 6, near the direct return trap, would get air-bound at times. This would prevent the check valve from opening to admit water into the trap tank, hence the trap would not operate as often as it should. I remedied this trouble by drilling and tapping the bonnet of the check valve for a ½-in. pipe, then connected a ½-in. swing check as shown in Fig. 6, at F. As the air pressure in the pipe and check is not high enough to keep the check valve closed tight, this air would escape, hence the trap filled with water.

---

The American Society of Safety Engineers is at work on a Safety Code for Compressed Air Machinery, which code will include rules for the construction and use of compressors, tanks, pipe lines, and the utilization apparatus where compressed air is the active agent. It is planned to have the code formulated by a sectional committee composed of representatives designated by the various bodies interested.

# Hammer Welded Steel Pipe

HAMMER WELDING is relatively new as compared with butt and lap welding for pipe and is used for the larger sizes, 24 to 96 in. diameter. Steel plates are rolled into tubular form with edges overlapping and the edges are then heated and hammer forged on an anvil block supported on a form inside the pipe as indicated in Fig. 1.

This gives a pipe free from rivets and projecting edges, with joint of high efficiency. A short length is

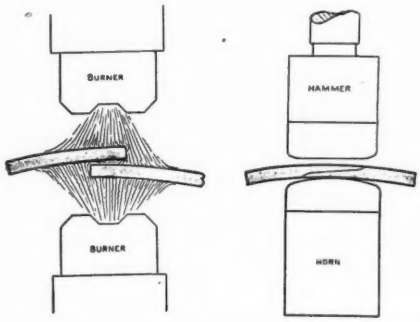



FIG. 1. METHODS OF HEATING AND FORGING HAMMER-WELD PIPE

heated, then forged to a good weld, then an adjoining length heated and forged, and so on until the entire length is welded.

After welding, the pipe is annealed to remove strains and is then treated on horizontal rolls to round and straighten it, and to remove scale which may have been formed during manufacture. Inspection and hydrostatic test follow, then application of a protective coating, if required, and marking with the test pressure which is 150 to 2000 lb. per sq. in., according to size, wall thickness and intended service.

This pipe may be fitted with various kinds of joints and nozzles on special machinery designed for the purpose.

Wall thicknesses are made from ¼ in. to 1½ in., the material having a tensile strength of 50,000 lb. per sq. in.

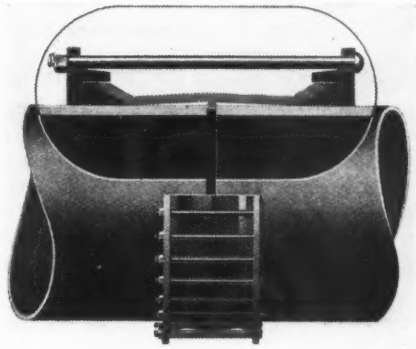


FIG. 2. PLAIN END COUPLING FOR PIPE

The advantages in increased flow, convenience in handling and installing of a pipe smooth and free of projections is obvious, particularly where clamped joints are to be made or outlet nozzles bolted on. Some of the joints used are shown in Figs. 2 and 3.

THE SOCIETY OF GERMAN ENGINEERS, at its latest annual meeting listened to a paper advocating the use of steam at pressures up to 900 lb. From the standpoint of heat economy it was claimed that engines utilizing several stages proved far superior with steam at 450 lb. than the best engines operating with superheated steam at ordinary pressures.

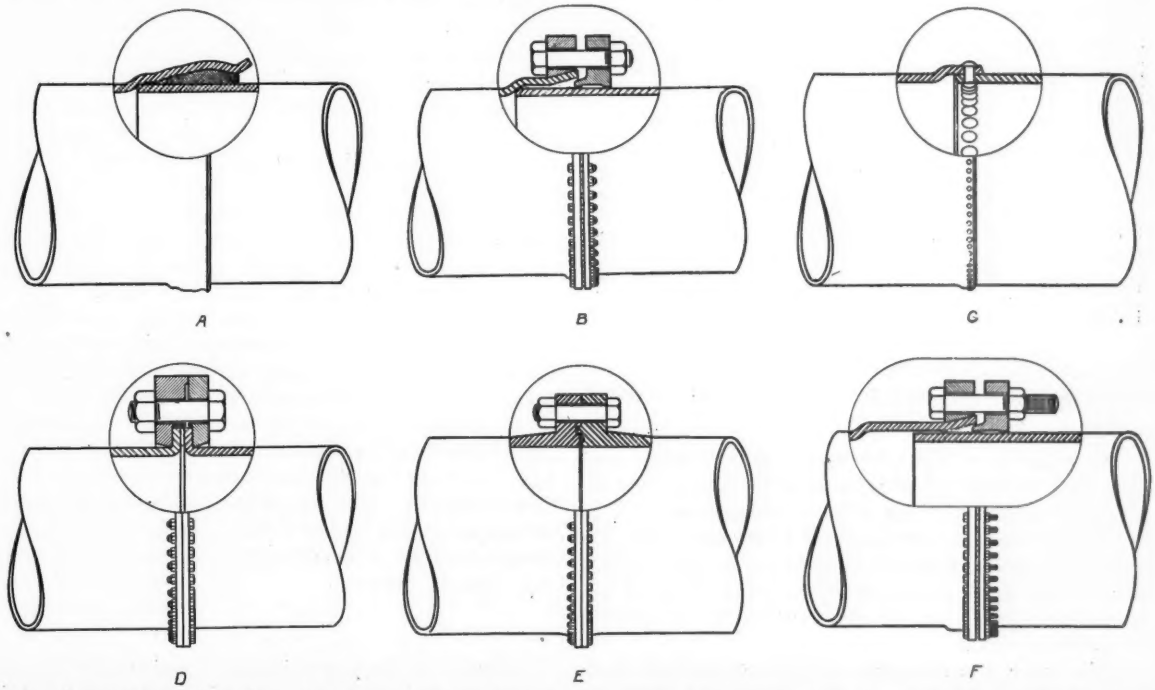



FIG. 3. EXAMPLES OF JOINTS: A, BELL AND SPIGOT; B, FLANGED BELL AND SPIGOT; C, STRAIGHT BUMPED JOINT; D, LOOSE FLANGE JOINT; E, WELDED FLANGE JOINT; F, EXPANSION JOINT

## Furnace Redesigned to Burn Shavings

THE ACCOMPANYING sketches show the setting and design of the boiler and furnace before and after redesigning, which is used for making steam for one 75-hp. common slide valve non-condensing engine, one dry kiln with 2000 sq. ft. of radiation and 1500 sq. ft. of coil radiation for heating the building, at Thompson, Hubman & Fisher Mills, North Tonawanda.

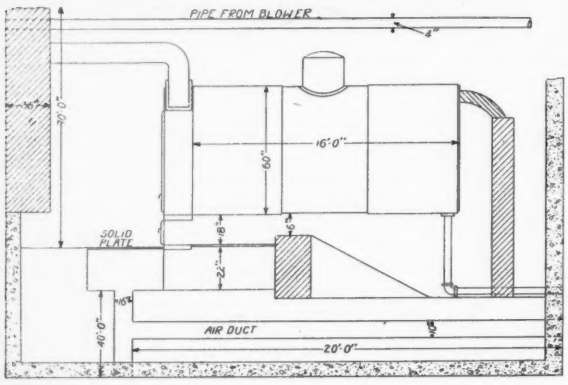



FIG 1

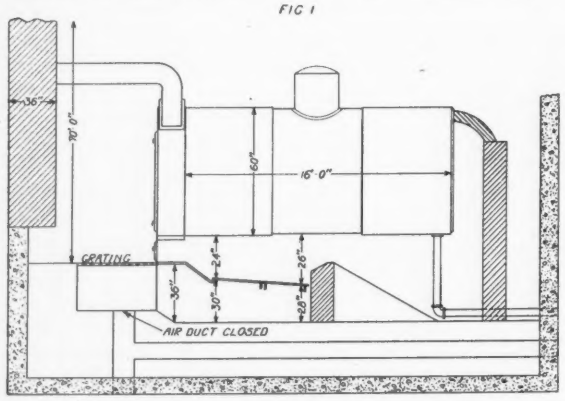



FIG.2

FIG. 1. ORIGINAL FURNACE DESIGN

FIG. 2. REDESIGNED FURNACE GIVES GREATER COMBUSTION SPACE

The boiler is of the horizontal return tubular type 60 in. in diameter by 16 ft. long with forty-four 4-in. tubes, carrying 100 lb. and 80 rated horsepower.

The fuel used is shavings and bituminous coal, the amount of shavings used is according to the class of work in the mill; there are times when they do not make enough shavings to run the boiler for even a few hours a week.

This boiler was set about 12 yr. ago and has been a source of trouble to the owners in the way of making steam and being very wasteful in the burning of fuel. Several engineers had looked this unit over at different times and advised to take it out and put in a new boiler, as they claimed it was not of ample size to carry the load. The mill hands and different operating engineers were of the opinion that there was lack of draft and in attempting to overcome this they cut holes through the outside of the building, making one air duct 16 in. in diameter with the inlet opening 40 ft. from the ash pit and another at right angles 10 in. in diameter with the opening 20 ft. from the ash pit. These ducts entered at a pit in the front of the boiler, which was covered with a solid plate at all times and when the wind was in a certain direction, instead of giving draft there would be a suction which would form a vacuum under the grate and the heat from the fire would be drawn downward and burn out the grates. In addition to the two air ducts, a 6-in. pipe was placed from the shaving fan in the mill to the chimney to form induced draft.

With all these attempts to make draft, they were unsuccessful. The grate bars were of such design that it was impossible for ash to pass through and the fire had to be pulled from the furnace when it was necessary to clean, which was at the noon hour in the summer months and once in the morning, at noon and the afternoon in the colder winter months. This caused the mill to be shut down at least 2 hr. a day. The grate bars were 5 ft. long and would warp in a very short time.

On looking this installation over, it was found impossible to raise the boiler without entailing a large expense, besides having the mill shut down while this was being done. The time allotted by the company to redesign the furnace and to make such changes as would be necessary to put this unit on an efficient basis was from Saturday noon until Monday morning.

In order to do this, it was necessary to lower the ash pit to 36 in. and install a depression plate, with a new set of grates, besides moving the bridge wall back 8½ in., lowering the bridge wall, putting a grating over the pit in the front of the boiler to admit air up under the grates and closing many large and small air leaks about the setting and breeching.

In addition to installing new grates and depression plate, an automatic damper regulator of the hydraulic type was installed and the damper is set in an almost closed position. The saving in fuel for the generating of steam in this boiler is far greater than what the company or the engineers expected who had condemned this unit as useless.

CHAS. J. MILLER.

---

TRYING to get something for nothing is a weakness of human nature, while something gotten for nothing is rarely worth the getting.

## Renewing Pump Liners

RECENTLY it became necessary to renew the brass pump liners in our reciprocating feed pumps. Inasmuch as it took two men 8 hr. to do the job, or twice what I expected, and as the job in question is not seen every day, it may be of interest to some of the readers to learn just how it is done.

First, the pump to be operated upon must be shut down and another put on the line if necessary to continuous service—that the pump in question may be properly cooled off for the men to work on without discomfort.

The pump is then stripped of all running gear, and the pistons withdrawn and carefully laid on one side.

The liners in question on this job were completely worn through on the bottom side, and only had to be ripped about 2 in. at each end with suitable chisel to release their grip within the casting.

Of course in this case, where the liners were badly cut, it was almost impossible to hold any water packing on the water pistons so rapid was the cutting action. In fact, the last six days of operation before the pumps had been dismantled, the new water rings had been worn so completely as to be useless.

I used to think at one time that if the liners became worn through that the water would bypass under this liner, which is not so—but rather leaks through the soft packing water rings on piston, as already mentioned.

This is so in the majority of pumps because there is no cored space beneath the liners—the cylinders are simply bored out and the liners pulled in, for the sake of having a renewable surface and partly to have a non-rusting anti-friction surface.

After the worn liners in question had been removed, the mechanic's helper got busy with scrapers and sandpaper and cleaned out thoroughly the inner surfaces of the water cylinders preparatory to drawing in the new brasses.

The new liners coming from the shop were 6 in. inside diameter and about 18 in. long, of ⅛-in. material, non-tapered and perfectly smooth on both sides.

The mechanic then tried them for fit, which, by the way, was supposed to be about three-thousandths larger than the bore in the pump. He rough filed a mild taper on one end to get it started properly, then the "pulling in bar" was inserted within the pump from the steam end.

The pump end of this rod held a male ended plug head, supposed to push in on the new liner without distorting its shape, while at the other end of this long rod was placed a larger plate to take the direct strain on pulling in operations.

This head plate rested against the head of steam end, and between the studs.

The bar, of course, being provided with a long running thread of about six threads to the inch, insures ample power when the inch-and-a-half nuts are backed up by sufficient beef.

So eventually they were coaxed into place. There is no beading or any other means of holding them in place—depending wholly on the friction or resistance required at drawing in. Should they become loose, they are of course useless.

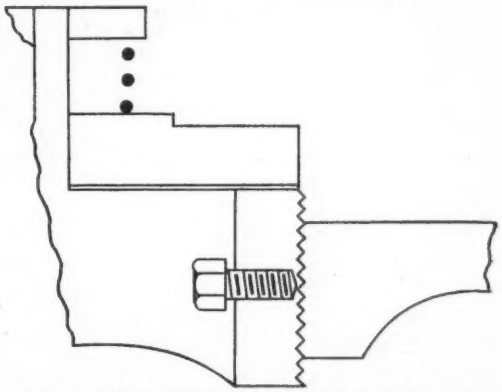
There remains, then, but to assemble the running gear, putting in new packing all around, and with a proper setting of the valves, the pump should be nearly as good as new.

The steam cylinders contain no such arrangement of liners, as for that end, service would be unnecessary.

HARRY A. LIVINGSTON.

## Temporary Repair to Pump

WE NEEDED a service pump to replace one that had gone bad, and the management, feeling the need for economies in every direction, directed us to purchase a used pump which was offered by a local machinery dealer. We put it in service, and before long we encountered knocking and unsatisfactory operation, and inspection revealed that several of the valve seats, where they were screwed into the pump casing, were loose, having been doctored up previously with packing and iron cement. Even though the purchase was made against our recommendation, it was up to us to make



METHOD OF USING TAP SCREW TO HOLD VALVE SEAT IN PLACE

it go and keep the outfit going, so we effected a remedy by taking out the valve seats which had shown signs of loosening, putting in four tap screws in each one, and using these to hold them in place firmly, in the manner shown in the accompanying sketch. This make shift repair job was done several months ago and the pump is continuing to do the work, though as soon as business conditions improve we shall be able to convince the powers that be that it will be more economical to buy a new unit.

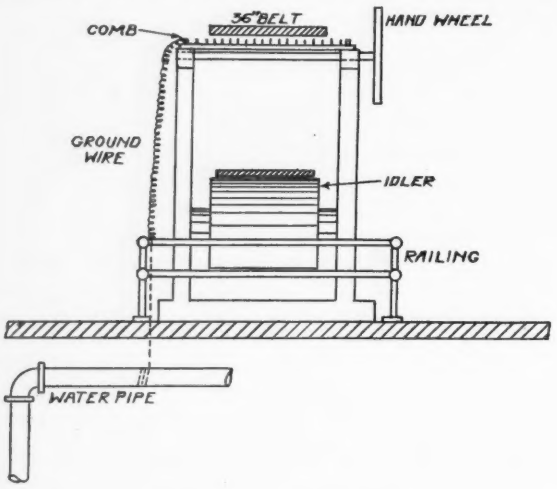
M. A. SALLER.

## Overcoming Static Annoyance

I RECENTLY visited a friend who operates a small electric plant. He complained of the disagreeable crackling noise, made by the static electricity from a 36-in. driving belt, passing over a hand-wheel shaft, at the top of the belt-tightener frame. I suggested, and helped him to make, a comb, a piece of 0000 wire, flattened at the ends, with teeth, made of No. 6 wire, 2 in. long, and 2 in. apart soldered on it. This was secured across the frame, and held in place with cap-bolt nuts, and fiber washers as insulators. The belt would then run clear of the teeth by about 2 in. I then left, telling him to run a good ground wire.

Meeting him later, he told me my change wouldn't work, that the noise was as bad as it was before. On

going to investigate the trouble, I found that he had "grounded" on the iron railing, the posts of which were screwed to the dry, hardwood floor. On connecting




COMB AND GROUND CONNECTION FOR COLLECTING STATIC ELECTRICITY FROM BELT

the ground wire to a water pipe in the cellar, as shown by the dotted line in the sketch, all noise from the static ceased. M. M. Brown.

## Steam Pressure Gage Connections

Figures 1 and 2 show gages connected somewhat differently from the usual method. By opening cock E, Fig. 1, any sediment or scale above the cock will be blown out with no danger of emptying the trap. To blow out the trap, the valve D is closed, the plug B removed and the valve again opened. The reason a cock is not placed at B is that a careless operator could allow steam at a high pressure to reach the gage frequently by neglecting to close cock A.

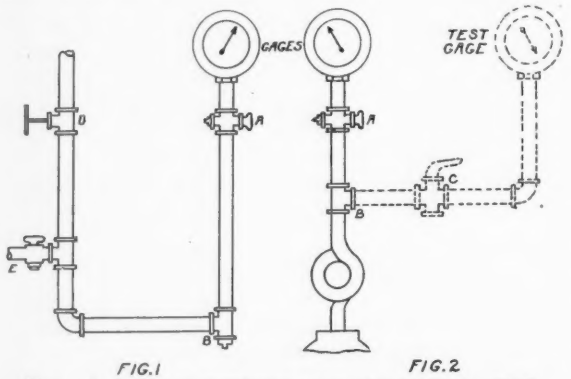



Fig. 1. Steam pressure gage connection with cleanout provisions

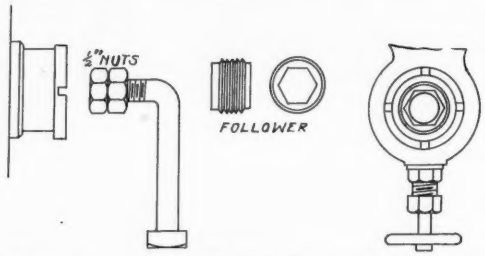
Fig. 2. Piping for pressure gage with test gage connection

If the short piece of pipe between the tee and the elbow is made ½ in. in size, there will be small chances of any trouble from blockage. In Fig. 2, an addition of a tee and a plug at B to the usual outfit is an improvement. By closing cock A the ring trap, or syphon as it is called, can be blown out by removing the plug. By screwing in a cock, nipples and an elbow attached, as shown by the dotted lines, a test gage can be used to show whether the regular gage is correct.

J. E. Noble.

## Emergency Wrench for Lubricator

Several bull's eye lubricators about the plant gave but little trouble with the exception of an occasional leaky glass gasket which was readily tightened with the wrench furnished with the lubricators when put up.



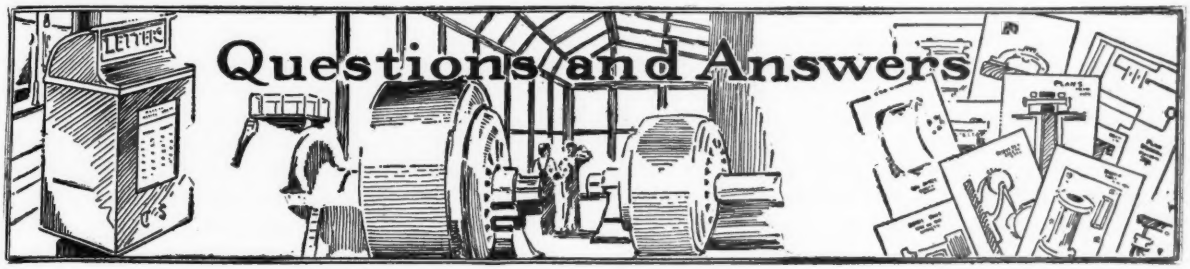

IMPROVISED WRENCH FOR TIGHTENING FOLLOWER ON LUBRICATOR

The wrench became misplaced, as was found out, when one of the register glasses began to leak badly. At first not a thing could be found that would enter the hexagonal openings in the followers that drew down the glass and gasket. By chance a half-inch nut from some nearby temporary repair rigging was slipped into it. It fitted to a nicety. It did not take long to lock two of them onto a bolt, the head end of which was bent into a satisfactory handle. Frank W. Bentley, Jr.

## Piston Rings and Counterbore

In the case mentioned by Mr. Hurst in Nov. 1 issue, under this heading, it is probable that too much of the packing ring ran over the bore. Personally I think a ring should run over, or a shoulder will in time be worn. I was on a job of cylinder boring a few years ago, where the ring had worn a considerable shoulder at the end of the stroke. Of course it is not necessary to have the ring overrun much, say ¼ or 1/5 of the width of the ring. Tom Jones.

U. S. Civil Service Commission announces examinations for junior aid ($720 to $840 a year) and laboratory apprentice ($540 a year), to fill vacancies in the scientific staff of the Bureau of Standards for duty in Washington, D. C., and in positions requiring similar qualifications. Applications will be received until further notice. Appointees whose ability and qualifications justify such action will also be allowed any bonus granted by Congress (at present $20 a month), beginning with the second month of acceptable service. For the position of junior aid, applicants must have reached their eighteenth but not their twenty-third birthday on the date of making oath to the application. For the position of laboratory apprentice, applicants must have reached their sixteenth but not their twenty-first birthday on the date of making oath to the application. These age limits do not apply to persons entitled to preference because of military or naval service. Apply for Form 1312, stating examination title.




## Wood Burning Stoker

I HAVE charge of three 72-in. by 16-ft. horizontal return tubular boilers equipped with Dutch oven furnaces for burning wood shavings, blocks and waste. The fuel is fed to the furnace by gravity from a cyclone separator. The velocity of the air to the separator is not entirely eliminated and there is a heavy down draft in the feed pipe to the furnace which causes a good deal of trouble by burning out the furnace lining. Would it be possible to do away with this method of feed and substitute chain grates or some such stoker to be fed by a conveyor of some kind? Any system that is to be installed must prevent fire from working back into the feed.

In my opinion, our present system could be replaced by simple hand firing with a saving in the cost of making steam. N. P.

## Lightning Arrester on Short Overhead Line

I WOULD greatly appreciate the opinion of some of the readers in regard to a problem that confronts me. Six 500,000 c. m. cables carying 3-phase, 60 cycle, 550-v. alternating current run overhead from the switchboard in the powerhouse, over the roofs of adjoining buildings, a distance of a couple of hundred feet to a point where they supply the current to a 500 and to a 750-hp. motor. The cables are of the weatherproof type. The question is, at the point where the cables leave the powerhouse, should they be provided with lightning arresters or not? C. S. C.

## Twisted Valve Stems

THE STEAM valve stems on a 12 by 36-in. Corliss engine were found to be twisted, causing the valve to remain open with the dashpot piston down. On looking for the cause, we found the stems free and the valves well lubricated. This same thing happened on another engine of the same size and make some time ago, for which we could find no cause.

What is the opinion of the readers of Power Plant Engineering as to the cause of this trouble? T. S. K.

## Crank Case Leak

CONCERNING THE question asked by R. C. on the subject of a crank case leak, would say that the writer had a somewhat annoying experience on three twin cylinder vertical gas engines some years ago when every few weeks annoying leakage would take place from under foundation frame of engine and cause a mess. The engine ran almost continuously; hence a quick repair was required. We tried to locate the leaks, but could not find anything in the base which looked as if it might cause trouble; we reasoned that the chaplet holes and plugs were at fault. We tried red lead, iron borings and sal ammoniac. We brushed entire base with an iron cement and dried it with a torch. The only result was that the bearings ran warmer and still the leakage continued. In desperation we tried litharge and glycerine, brushed in and dried with a torch; no better result; leaks less serious, but still on the job. We tried cursing the engine roundly; no results except, perhaps, increased leakage.

Then I bought a gallon of silica-graphite paint and poured the contents into the crankcase while the engine was running; it was therefore distributed all over the interior of the engine. To our delight, this engine did not leak again after the oil which had already escaped from base had oozed out from the top of the foundation, and in the two years since that time no further escape of oil has occurred. After a month, we treated the other two engines in the same way and the leakage stopped in them, also.

It is probable that the graphite and silica had settled into the minute pores and openings in the base and had thus stopped the leakage. No harm befell the bearings; they ran continuously. I presume the addition of a few pounds of powdered flake graphite might be as effective, but it may not. The linseed oil which is contained in the paint might help to settle the graphite better. D. L. FAGNAN.

## Is the Boiler Level?

IF E. B. F., WHEN cleaning out the boiler, will close the blowoff valve, and with the front manhead out, run a little water in the boiler; if the boiler is low in front the water will stand in a pool at the rear end, gradually enlarging until the front is reached.

Or get a straightedge and level on top of the boiler. I would not depend too much on the nozzle of the safety valve, for it is not always level; and certainly never go by the brick work to determine whether or not anything is level; it might be, and then again it might not.

TOM JONES.

## Centrifugal Pump Capacity

HOW HIGH will a single-stage centrifugal pump lift water; also a two and three-stage pump?

2. Recently, we installed a single-stage pump rated at 800 g.p.m., at a 40 ft. head. What will be its capacity under a head of 70 ft.? M. J. E.

A. If by lift you mean that height to which such a pump will force water, it may be said that the head pumped against is limited only by the safe impeller speed.

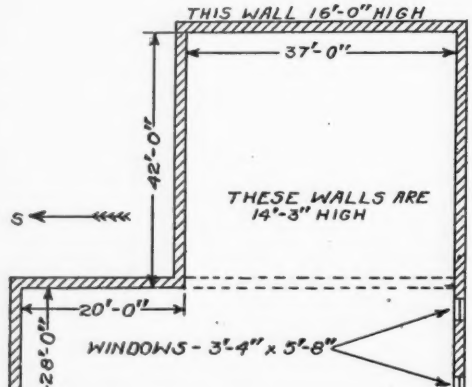
For a single-stage pump, the head is usually kept under 125 ft. By multiplying the stages, however, the head may be increased very materially. Suction lift is usually limited to about 20 ft., but may be increased to as much as 25 ft. The number of stages does not affect the suction lift.

2. A pump designed for variable head operation should have a fairly flat characteristic, i.e., the efficiency should remain nearly the same over a wide range of heads. If such a pump is designed to deliver 800 g.p.m., at 40 ft., it should deliver at 70 ft., with the same power input, $40 \div 70 \times 800 = 457$ g.p.m. If the pump is designed for constant head operation it is likely that for heads other than that designed for, the efficiency will drop off materially from the maximum. In such a case, the product of the head and the capacity at any given head will be less than that at the head designed for, and the capacity cannot be determined by a simple proportion; the efficiency must be known at this head.

## Garage Heating

CAN YOU give me information on the pipe coil radiation surface that will be required in a garage of the size shown in the sketch? All walls except the south are exposed. The wing end of the building has a curved roof. The mean height of the west wall is 16 ft.; all other walls are 14.25 ft. high. There are doors and windows as indicated; and there is a skylight having an area of $28 \times 14$, or 392 sq. ft. The walls are of corrugated iron and the floor concrete. The building is to be kept at 50 deg. with an outside temperature of zero.

G. R.




PLAN OF GARAGE

A. For the kind of building you describe, where the temperature is to be kept at 50 deg. with zero outside, for all practical purposes no distinction need necessarily be made between the walls, windows, doors, roofs and sky lights. A transmission factor of 60 B.t.u. per sq. ft. per hr. for a temperature difference of 50 deg. may be allowed. Factors for north, east and west exposure should be taken at 1.3, 1.1 and 1.2 respectively. A factor of 1.3 may be allowed for leakage. The floor can be assumed as transmitting 5 B.t.u. per sq. ft. per hr.

| | | B.t.u. |
|---|---|---|
| North wall | $70 \times 14.25 \times 60 \times 1.3 =$ | 77,800 |
| East wall | $57 \times 14.25 \times 60 \times 1.1 =$ | 53,600 |
| South walls | $70 \times 14.25 \times 60 =$ | 60,000 |
| West walls | $(20 \times 14.25 + 37 \times 16 \times 1.2)60 =$ | 59,700 |
| Roof | $(42 \times 37 + 28 \times 57)60 =$ | 189,000 |
| Floor | $(42 \times 37 + 28 \times 57)5 =$ | 15,750 |
| Total | | 455,850 |
| Leakage | $455{,}850 \times 0.3 =$ | 137,000 |
| | | 592,850 |

Using steam at 2 lb. pressure in direct radiation coils, a transmission allowance of 300 B.t.u. per sq. ft. per hr. for a room temperature of 50 deg. may be made. The necessary radiating surface is then found to be $593{,}000 \div 300 = 1977$ sq. ft.

As a boiler horsepower can furnish approximately 33,500 B.t.u. per hr., you will require $593{,}000 \div 33{,}500 = 18$ hp., about, assuming no losses between boiler and heating system.

## Oil Heater

I AM contemplating installing a heating coil in a 1000-bbl. oil tank and would appreciate some information pertaining to the design.

The tank is about 20 ft. in diameter by 16 ft. high. Crude oil having a specific gravity of about 18 deg. Baume is used. It is to be pumped through a 3-in. line a distance of about 3 mi. It becomes very thick and heavy in cold weather and will have to be heated. We will probably want to pump about half the tank capacity in 6 hr. The oil will probably have to be heated to about 100 deg. What pressure should we carry? We have an old 35-hp. boiler that will carry 40 lb. Will it be suitable for the purpose? S. H.

A. It will be unnecessary to heat the whole tank at one time. It is sufficient that only the oil near the discharge pipe be heated. For this purpose it is necessary to arrange a steam coil in the tank at the discharge opening. A small diameter pipe should be used in order that the heat transfer may be as rapid and as complete as possible. It should, however, not be so small that the pressure drop through the coil would be excessive.

Taking the specific heat of the oil at 0.55 and assuming an initial temperature of zero deg. F., the heat required would be $Q = 0.55\ (100—0) = 55$ B.t.u. per pound. As your maximum demand is 500 bbl. in 6 hr. or 437 lb. per min., you will require $Q = 437 \times 55 =$ 24,000 B.t.u. per min.

Using steam at 40 lb. and discharging the condensate at 100 deg., the heat given up per pound of steam is $Q_1 = 1178.5 - (100 - 32) = 1110.5$ B.t.u. where 1178.5 is the total heat of the steam (steam tables) and (100—32) is the heat of the liquid above 32 deg.

The steam required will be $24{,}000 \div 1110.5 = 21.6$ lb. per min. or 1286 lb. per hr. This represents a boiler capacity of $1296 \times 1110.5 \div (34.5 \times 970.4) = 43$ boiler hp. The product $34.5 \times 970.4$ represents the B.t.u. per hour equivalent to one boiler horsepower.

Your 35-hp. boiler can be made to carry the load with an overload capacity of about 23 per cent.

The extent of heating surface, S, will be

$$S = W (H - q) \div Ud$$

Where W is the weight of steam per hour, (H — q) is the heat given up per pound of steam which equals 1110.5 B.t.u., U is the coefficient of heat transmission through the pipe which may vary from 100 to 1000 depending on the material, thickness, size, shape and condition of the surface and on the velocity of steam and oil and also on the viscosity. A safe figure is difficult to arrive at, but we may take, say, 200, for want of more accurate data.

The mean temperature difference,

$$d = [(298 + 100) \div 2] - [(100 + 0) \div 2] = 149$$

deg. The quantity 298 is the temperature of steam at 40 lb., pressure.

Substituting then in our original equation, we find

$$S = 1296 \times 1110.5 \div (200 \times 149)$$

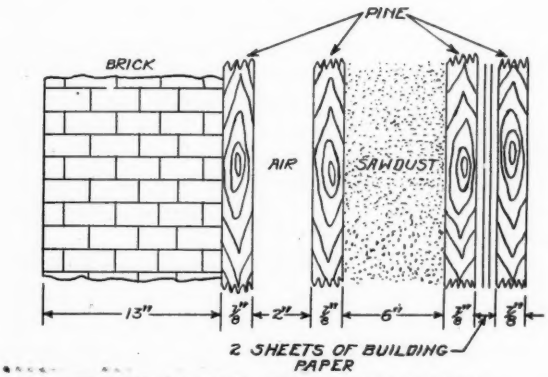
$$S = 48.2 \text{ sq. ft.}$$

Assuming a one-inch pipe, 0.262 sq. ft. per ft., there will be required $48.2 \div 0.262 = 184$ ft.

As no losses have been taken into consideration, these figures will have to be increased somewhat in order to be compatible with conditions as they exist.

## Heat Transmission Through Ice Storage Wall

How can I calculate the heat transmission through the walls of our ice storage house? The wall is made up of 13 in. of brick, 7/8 in. pine, 2 in. air space, 7/8 in. pine, 6 in. sawdust and shavings, 7/8 in. pine, two thicknesses of building paper, and another 7/8-in. layer of pine boarding. V. N.




SECTION OF WALL OF ICE STORAGE ROOM

A. The coefficient of heat transmission in B.t.u. per sq. ft. per deg. difference in temperature per hour, through such a wall may be found from the equation

$$K = 1 \div [(X_1 \div C_1) + (X_2 \div C_2) + (X_3 \div C_3) + (X_4 \div C_4)]$$

where X is the thickness of the various materials in inches and C the coefficient of transmission through each material. The values for C are for brick, 4.66, for pine across the grain, 0.75, for air, 0.82, and for sawdust and shavings, 0.25. Substituting these values in the equation, we find,

$$K = 1 \div [(13 \div 4.66) + (4 \times 7/8 \div 0.75) + (2 \div 0.82) + (6 \div 0.25)]$$

$K = 1 \div 33.9 = 0.0295$ B.t.u. per sq. ft. per deg. per hr.

## Selecting the Fuel

Natural gas available here tests between 950 and 1050 B.t.u. per cu. ft. It sells at $0.45 per thousand for the first 30,000 cu. ft. and $0.225 for all thereafter. How would this compare with coal suitable for steaming purposes at $6.80 per ton, or with fuel oil at $1.15 per bbl., all prices f.o.b. plant? W. B. E.

A. In determining the kind of fuel best adapted for any particular installation, the figure to be looked for is the actual cost of producing a given quantity of product.

For most purposes we can figure the cost of producing steam as so many cents per 1000 lb., from and at 212 deg. F.

It is not sufficient for this purpose that the mere price of the fuel be considered. The efficiency of operation, functional depreciation on the equipment, interest on the investment, replacement and obsolescence charges, maintenance, labor and taxes must all be considered. Without detailed information on these items we can only figure the relative costs based on the cost of the fuel.

We will assume first that both oil and gas can be burned with the same overall efficiency of, say, 80 per cent, and that coal can be used with 70 per cent efficiency.

One ton of coal having a heating value of 13,000 B.t.u. per lb. will deliver to the boiler $13,000 \times 2000 \times 0.70 = 18,200,000$ B.t.u. To furnish this heat with oil having a heating value of 19,000 B.t.u. per lb. would require $18,200,000 \div 0.80 \div 19,000 = 1195$ lb. oil. Using gas there would be required $18,200,000 \div 0.80 \div 1000 = 22,750$ cu. ft.

In order to compete with coal at $6.80, oil could sell at $\$6.80 \div 1195 = \$0.0052$ per lb., or $1.61 per bbl. of 42 gal., or 315 lb. assuming a specific gravity of 26 deg. Baumé. Gas could sell at $\$6.80 \div 22.75 = \$0.299$ per 1000 cu. ft.

As 1195 lb. oil is equivalent to 22,750 cu. ft. of gas, to compete with oil, gas would have to sell at $1195 \div 315 \times \$1.15 \div 22,750 = \$0.192$ per thousand cu. ft.

## Diametral Pitch

What is meant by the term diametral pitch? H. A.

A. By diametral pitch is meant the ratio between the number of teeth on a gear and its pitch diameter in inches. The term is used merely for convenience and has no physical meaning. It is represented by an abstract number and resembles in many respects the value of *pi*, 3.1416, which is, of course, the ratio of circumference of a circle to its diameter, measured in the same units. In a similar way, diametral pitch is the ratio of the circumference of a gear, measured in terms of number of teeth in that circumference to the diameter measured in inches.

If "p" is the circular pitch, pitch circumference divided by the number of teeth, then the diametral pitch, $p_1$, is equal to $3.14 \div p$. If, for instance, we have an 18-in. gear having 50 teeth, the circular pitch would be $18 \times 3.14 \div 50 = 1.13$ in. The diametral pitch would be $50 \div 18 = 2.78$, or $3.14 \div 1.13 = 2.78$.

Gears are most frequently designated by the number of teeth and the diameter; the circumference is not usually stated directly as such.

# POWER PLANT ENGINEERING

Trade-Mark, Reg. U. S. Pat. Office

Issued the 1st and 15th of each month. Established over 25 yr.

Published by the TECHNICAL PUBLISHING CO.
537 South Dearborn Street, Chicago.
New York Office, 150 Nassau St.

Subscription price $2.00 a year in postal zones 1, 2, 3, 4 and 5, which include all postoffices within a distance of 1400 miles from Chicago.

Subscription price $2.50 a year in postal zones 6, 7 and 8, which include all postoffices more than 1400 miles from Chicago.

Copies, current issue, 15 cents; back numbers, 25 cents.

Notify us at once of any change of address, giving the old and the new address, so that your paper may always reach you promptly.


Copyright, 1921, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers.
Member, Audit Bureau of Circulations.

Circulation of this issue 22,000

CONTENTS


Steam for Battle Creek Sanitarium. Illustrated.....1131
Temperatures and Gas Velocities in Boiler Settings. By A. W. Binns and C. E. Joos. Illustrated.....1138
Risks in Handling and Storing Coal and Oil. By C. E. Paige .....1140
Value of Intercooling Compressed Air. By C. K. Bennett. Illustrated .....1142
Unaflow Engine Shows Low Steam Consumption. Illustrated.1144
A Compressorless Diesel Engine. Illustrated.....1146
Why the Engine Used Too Much Oil. By J. B. Dillon.....1147
Lightning Arresters—II. By V. E. Johnson. Illustrated....1148
Some Pointers on Induction Motor Troubles. By W. B. DeMuth .....1152
Fuses for Alternating Current Circuits. By Howard D. Matthews .....1153
Low Power Factor.....1153
Foreign Development in the Power Plant Field. By J. H. Blakey. Illustrated.....1154
Air Tank Explosion. By R. L. Hemingway. Illustrated.....1156
Trouble Hunting. By John Pierce. Illustrated.....1157
Limitations of Silent Chain Drives. By F. G. Anderson....1160
Power Plant Troubles. By H. A. Jahnke. Illustrated.....1161
Hammer Welded Steel Pipe. Illustrated.....1163
Letters Direct from the Plant: Furnace Redesigned to Burn Shavings. Renewing Pump Liners. Temporary Repair to Pump. Overcoming Static Annoyance. Steam Pressure Gage Connections. Emergency Wrench for Lubricator. Piston Rings and Counterbore. Illustrated.....1164
Questions and Answers: Wood Burning Stoker. Lightning Arrester on Short Overhead Line. Twisted Valve Stems. Crank Case Leak. Is the Boiler Level? Centrifugal Pump Capacity. Garage Heating. Oil Heater. Heat Transmission Through Ice Storage Wall. Selecting the Fuel. Diametral Pitch. Illustrated.....1167
Editorial: Unemployment. Establishing Records and Standards .....1170
Off Duty .....1171
New Type Vacuum Traps. Illustrated.....1172
New Fournier Type Thermometer Manufactured in U. S. Illustrated .....1173
Light Weight Generator Set. Illustrated.....1173
Improved Type of Contactor. Illustrated.....1174
How Is Your Generator Working?.....1175
News Notes .....1175
Catalog Notes .....1176


## Unemployment

As a remedy for unemployment, the best thing is work. No man who can get a job—any kind of a job—has a right to complain that he is out of work. He may not get as much pay as he has at some past time; he may not get what he is worth, even though he gets all that the work is worth. But he is using his time and effort to benefit himself and humanity, if the work is worth doing at all—and if it isn't he probably will soon find it out.

We need an awakening to the good old idea that the world owes a man a living when he has earned it—not before. If a man wants some particular kind of a job, he must prove that he is fitted for it by skill and experience. If he wants high wages, he must earn them. Work—doing the best we can at the job we have or can get, and trying to be worthy and worth the job ahead—is the cure for unemployment, and the only cure.

Anybody who has the fool idea that an employer can make jobs at will is on the wrong track. No employer can long pay for work for which there is no market. He may make goods for stock for a time, but he will soon come to the end of his resources, and if the goods are not salable, he has wasted the time of his workmen and his own resources. Building public works for which there is no use comes in the same class, but this does not apply to good roads, reclaiming waste land or improvements which are manifestly for public interest; and the recommendation of the Unemployment Conference that such works be carried on at present so far as possible is worthy of endorsement and action.

Every worker is entitled to a fair return for work that he does; but the product of his work must bear the cost of materials, machinery, buildings, marketing and supervision, and the price is fixed by the demand—by what somebody is willing to pay. If the worker wants high pay, he must expect to give a high value in work; and if workers demand more than they can earn, employers who have to sell the product will soon have no jobs to offer.

In the present crisis it is the duty of employers to get all the orders they can, so as to furnish all the jobs they can, but there is no obligation to make jobs where there is no market for product. It is the duty of the worker to do whatever useful work he can find; to give full return for the pay he gets, and to fit himself for a better job—then go get it, so that the next fellow can have a chance. Trying to "make a job last" is sure to result in a job lost.

The best remedy for unemployment is to go to work at something. Overhauling, repairing, adjusting, cleaning up, rearranging for future needs are best done when there is no rush of orders. Until every machine, every plant, every man's house and belongings are in the best condition that he can think of for the future, there is work to do, which, if not giving immediate profit will pay in the end. For such work the worker may not get high wages, but he will be employed, and will be hastening the day when the country and its industries will be back at a normal condition of production.

Get busy!

## Establishing Records and Standards

It is one thing to obtain a remarkably good result from one piece of equipment in a power plant, but it is a far different matter to maintain that record or one close to it in everyday operation. It is not a difficult matter to "stack" conditions and perhaps maintain them for a short run on any machine so that it is working to its best advantage, but frequently such an advantage causes losses in other parts of the plant which more than offset the gain in economy on the apparatus under test. It is, then, highly important that a distinction be made between a record performance and a standard performance.

In the large power plants of the country, test gangs are at work continuously going from one piece of equipment to another, investigating the causes of loss in economy and making recommendations to be followed in the routine operation of the plant. These test engineers do not expect those in charge of operation to obtain the highest efficiency of which the equipment is capable, but they do specify the conditions which they expect maintained and they know that if instructions are carefully followed, the over-all economy of the plant will be high. In other words, the ultimate result in that particular plant will be a function of conditions which are outside the control of the operating force and the standard set for any plant should be based upon these outside influences rather than upon what may have been accomplished over some particularly favorable period.

Most important among conditions outside the control of the operating force, is the per cent of rated load carried upon the plant and its variation throughout the day, and some central stations base their standard of operation on average load alone. In plants furnishing not only power but heat, such a standard would hardly be adequate, as weather conditions would influence conditions greatly, not only the outside temperature but the direction and velocity of wind, the humidity of the atmosphere and the barometric pressure. These conditions have their effect principally upon the amount of steam consumed so that an engineer would not go far wrong in basing his standard upon the combination of the power and heating demands placed upon the plant.

A record for any piece of apparatus may be established by a single test, run under most advantageous conditions, while a standard requires months of the most careful observation. The record is a most helpful guide in establishing standards and the operative should endeavor to achieve this record until a definite standard has been established for each important piece of equipment in the plant, but no plant can be expected to give highest economy until the relationship of varying conditions has been worked out to best advantage.

## Off Duty

In these turbulent times when all the world quivers with the tremors of disquiet and unrest; when the smoldering passions of war-scarred masses, ever ready to burst into flame, hold in jeopardy the security of our social organization, our minds at times are beset with worries and we become depressed with the apparent hopelessness of it all. We find it difficult to remove our thoughts from the depressing influence of the age, in spite of our willingness to do so. The tremendous importance of the issues of the day seems to demand our every thought.

And yet, what are these issues in their actuality? Notwithstanding their importance to us as humans, they are insignificant. Consider ourselves. Here we are, some 1600 millions of living organisms confined by the irresistible forces of gravitation to a speck of matter whirling in the infinite void. This speck of matter we call the world. These organisms or "so-called" reasonable human beings, endowed with an overwhelming amount of conceit, have taken it upon themselves to make their brief existence as miserable as possible. Instead of living in contentment and happiness we find them from time to time, divided into tribes, and afflicted with furious folly, charging each other in more or less successful endeavors to exterminate themselves; "all" as Flammarion puts it, "in order to maintain the microscopical divisions of a little globe into several anthills." The absurdity of it is truly astonishing.

In no way are these absurdities better revealed to our minds than in a study of the stars and the cosmical forces of nature. Nothing so completely confronts us with our own insignificance as a knowledge of the stars. The unfathomable distances of the starry universe reduce our own petty affairs to an insignificance almost beyond comprehension. And so, when the mind is weary and overwrought with the cares of your existence, hitch your wagon to a star or ride some winged Pegasus across the illimitable depths of stellar space to the scintillating Pleiades or to Perseus the gallant rescuer of Andromeda.

Like the flowers of the earth the stars are the flowers of the sky with blossoms eternally resplendent in the infinite meadows of the universe. As your knowledge of them grows their beauty will grow. The beauty of the nebula lies not alone in the fantastic configuration of the swirling atoms revealed to the eye, but rather in the train of thought which the spectacle induces, just as a knowledge of art lends beauty to the artist's picture.

Let your imagination soar—the mind is infinite and can penetrate the uttermost depths of the universe. There, in the contemplation of chaos will be found orderliness; the immutable laws of nature apply there with the same unerring precision that they do here on earth.

Learn to know the stars, their ways, their histories and their legends. They will always be your friends, and every evening as they emerge from below the eastern horizon to greet you, their radiance will dispel the shadows of a careworn mind and leave in their stead the inspiration which comes only from the pursuit of the higher intellectual pleasures of life.

### Power Plant Slogans

**Keep and Analyze Operating Records in Every Power Plant.**
**Develop Water Power Sites.**
**Promote Health and Safety in Power Plants.**
**Handle Coal and Ashes Mechanically.**
**Employ Engineers for Engineering Work.**

# New Type of Vacuum Traps

SHOWN in the illustrations is a novel vacuum trap which was first perfected during the war and applied in marine service on the S. S. Leviathan by the then chief engineer, Commander Vaughn V. Woodward, U. S. Navy, as a means for draining the low pressure turbines, replacing the customary main air pump drainage of these two large engines.

The trap is also suitable for draining turbines in stationary plants and for draining apparatus and systems using steam under vacuum, such as condensers, evaporators, vacuum pans, cooking kettles, etc., and for returning condensation of live steam heating systems to the boilers. Its use in place of a float controlled condensate pump is often practical and with a consequent elimination of the steam requirement for operating the pump.

The Wilmon vacuum trap, as it is called, can also be used for lifting, and when equipped with a counting

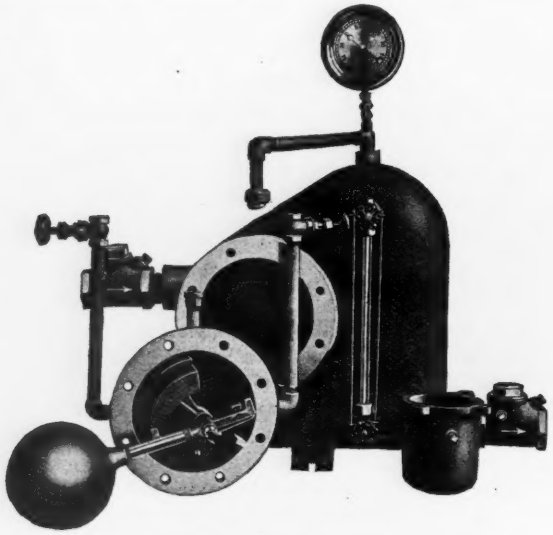


FIG. 1. WILMON VACUUM TRAP, COVER AND FLOAT MECHANISM REMOVED

device, it will perform the additional function of a meter, with greater precision.

Typical drainage of a steam turbine with the delivery of the condensate at a higher point of discharge is shown in the line cut. In marine installations, where the common practice is to drain the turbine directly into the main air pump, hot vapors must enter the air pump during a part of the time and thereby impair the vacuum. By the use of this trap, the turbine drains can be removed entirely from the main air pump and placed through the trap into the condenser, thereby insuring that no hot vapors enter the air pump to interfere with the vacuum.

By removing eight tap bolts, the entire working mechanism, mounted on a flange, can be taken out as a unit. A compound pressure gage on top and a sight glass on the front, give a double check on the operation of the trap. Where a permanent record of the operation of the trap is desired, a recording gage with electrical contacts may be added.

The receiving chamber of the trap is under vacuum while the water is collecting in the trap, and under atmospheric pressure during discharge. Back flow is prevented by check valves on the inlet and outlet lines.

Change of pressure in the receiving chamber from vacuum to atmospheric and vice versa, is accomplished by an oscillating disk covering three ports, which makes a quick shift from one operating position to the other. One of these positions connects the receiving chamber

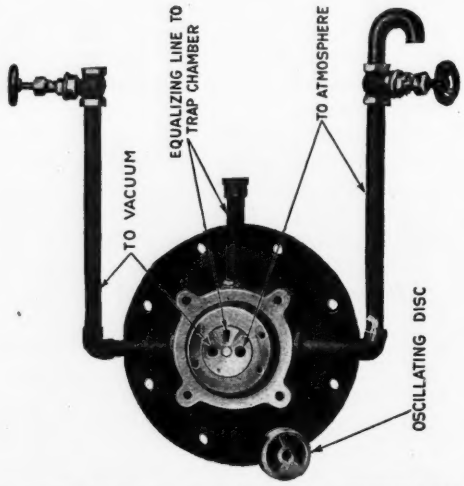



FIG. 2. TRAP DISK AND SEAT SHOWING CONTROLLING PORTS AND THEIR OPERATION

with the vacuum system, and the other position connects the chamber with the atmospheric line, the communication being effected in both instances through the equaling line which connects the middle port to a top opening in the receiving chamber.

The disk and thrust bearing, and the spring which holds these parts in place, are in a separate outer cham-

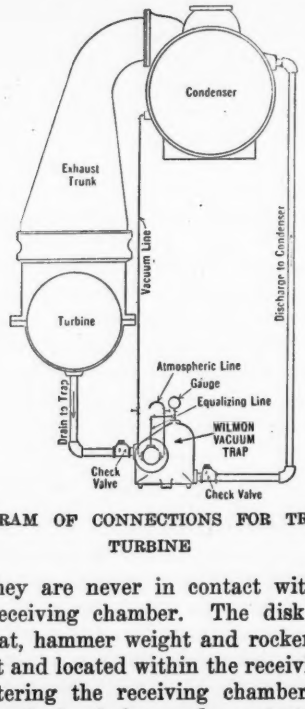



FIG. 3. DIAGRAM OF CONNECTIONS FOR TRAP DRAINING TURBINE

ber, where they are never in contact with the liquid within the receiving chamber. The disk is operated by a lever float, hammer weight and rocker arm, all on the same shaft and located within the receiving chamber.

Water entering the receiving chamber carries the float upward as the level rises, and a contact point on the

float stem, between the float and its fulcrum, rotates the weight, until as the latter passes dead center, it drops onto the contact point on the rocker arm and partially rotates the oscillating disk to the opposite position. This shuts off the vacuum line and opens the receiving chamber to atmospheric pressure through the atmospheric and equalizing lines. Water is then forced through the trap outlet, if the latter is connected to a vacuum, or drains by gravity if connected to atmosphere.

As the float falls with the water level, the contact point beyond the fulcrum on the float stem lifts the weight past dead center and lets it drop in the opposite direction, when it hits the opposite end of the rocker arm and shifts the disk. This cuts off the atmospheric line, connects the vacuum and equalizing lines and brings the receiving chamber under vacuum again. The cycle repeats at a rate determined by the amount of water accumulating. More than three discharges per minute have been obtained with perfect action. The disk requires no adjustment either before trap installation or during service, but may be seen and reached while the trap is in operation, without in any way interfering with the trap action.

The absence of liquids at the controlling ports permits salty or alkaline water to be handled without fear of salting or eroding the operating mechanism.

The fact that the liquid passes through no restricted passages gives the trap a very high capacity, which is limited only by the size of the inlet and outlet openings of the trap. The 2-in. trap, for instance, handles 1800 to 2100 gal. of water per hour. This capacity will vary depending on the lift of the discharge.

The Wilmon vacuum trap is manufactured by P. H. Gill & Sons Forge & Machine Works, Brooklyn, N. Y.

## New Fournier Type Thermometer Manufactured in U. S.

A NEW indicating thermometer is being manufactured in the United States by the Sarco Co., Inc., under a license granted by the Societe des Appareils Fournier of Paris, covering the use of a large number of United States patents granted to Prof. Fournier of the College of the Sorbonne, University of Paris, who is one of the best known authorities in the world on thermometric design. As a preliminary to taking up this work, the Sarco Co. made an investigation in the Fournier factory in Paris, of the methods of design and manufacture and particularly of filling and calibration.

The Fournier instruments are of the saturated vapor type, based on the principle that the tension of a saturated vapor is a function of the temperature of the vapor and is constant irrespective of the volume occupied. Therefore, the pressure within the apparatus is unvaried for any given temperature and changes only with the temperature irrespective of any other outside influences.

These thermometers can be made for any given temperature from minus 90 deg. F., to plus 1300 deg. F. The fillings used vary from an inert gas, for the lowest temperature, to mercury vapor for the highest. Between these there are a number of special fillings developed by Prof. Fournier, mainly of the benzine series. The use of these different fillings involves a certain amount of limitation in the range to be adopted. The following are some of the outside limits of temperature ranges due to the physical properties of the fillings used: minus 90 to plus 90 deg. F., 0 to 240 deg. F., 150 to 350 deg. F., 300 to 700 deg. F., 700 to 1300 deg. F. Within these ranges practically any desired range can be specified.

One of the important features of the Fournier apparatus is the use of more than one liquid or gas filling. For instance, where conditions require it, a thermometer is made with a saturated vapor in the bulb and a liquid filling the transmission tube. The liquid in the transmission tube is of a very low coefficient of expansion and as a result, these thermometers can be furnished with practically any desired length of connection tubing, say up to 500 ft.

Another feature is that the thermometer dial case and its interior mechanism also the connection tubing may be exposed to a temperature higher or lower than the temperature of the bulb without affecting in the least the temperature indicated which is at all times that of the bulb.

NEW SARCO THERMOMETER

The operating mechanism consists of double Bourdon tubes, operating through a series of levers instead of through gears. The pointer is controlled by a strong hair spring, which takes up any back lash and provides what is practically a dead-beat movement. The cases are black enameled and are dust and moisture proof.

## Light Weight Generator Sets

RECENTLY there has been placed upon the market a Westinghouse-Sturtevant light set of light weight, compactness and economy of operation.

The frame is made oil and dust-proof, with large openings to give ready access to all parts and has in the top an oil reservoir for the lubricating system. The distance piece which separates the cylinder and frame encloses a watershed partition and stuffing-box to prevent the water from the cylinder leaking into the frame and the oil in the frame from being carried into the cylinder.

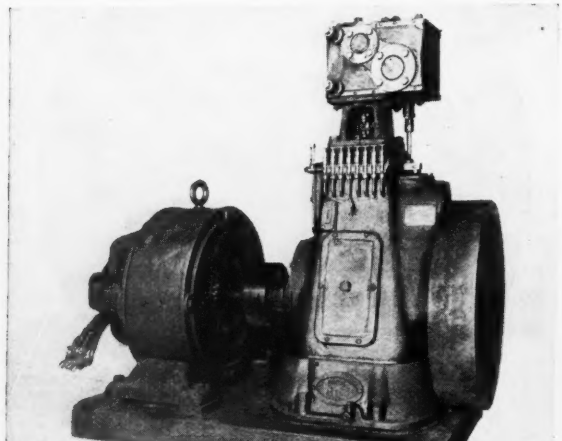
The valve is of the piston type and operates in a

renewable bushing, which forms the valve ports. It is controlled by a Rites inertia governor, placed in a heavy flywheel, to hold the regulation to 1.5 per cent.

Lubrication is automatic and continuous, requiring no independent tank or reservoir. In engines having gravity type lubrication, the oil is pumped from the reservoir in the base by a chain-driven rotary pump which is entirely submerged in the oil, to the upper reservoir cast in the top of the frame, whence it flows by gravity through brass pipes to the various bearing surfaces requiring oil, then back to the reservoir in the base where it is strained and repumped. Where a forced feed system of lubrication is furnished, the submerged pump forces the oil under pressure through brass pipes direct to all parts requiring lubrication. The oil then drains back to the base, where it is strained and again forced through the system. An oil well level gage is supplied, attached to the outside of the base.

Westinghouse generators forming a part of these sets have the frame forged from open hearth steel.

Armature coils are so constructed that no cross-overs on edge occur and both armature and field windings are impregnated with a special compound for resisting moisture and salt atmosphere.



WESTINGHOUSE-STURTEVANT GENERATING SET

Design is such that air can circulate freely through the generator, coming in contact with all internal parts and thus eliminating the possibility of internal hot spots.

Sparkless commutation results from the application of commutating poles, the brush position being fixed before the set leaves the factory and never requiring adjustment.

## Improved Type of Contactor

THE GENERAL ELECTRIC CO. has recently developed two new contactors, one for 1000 and the other for 2000 amp., for 600-v. a.c. circuits. Both sizes are made for two or three-wire circuits, as desired.

The design of the contact parts and arc chutes of the 1000-amp. contactor has been greatly improved over those of former varieties. The contactors carry three sets of tips, designated A, B and C, in Fig. 1. A are the arcing tips, B the intermediate, and C the main current carrying tips. When the contactor opens, first the main tips open, which puts the blowout coil across the line. Next the intermediate tips open, and lastly the arcing tips. This construction reduces the burning of the main current carrying tips to a negligible amount. In closing, the order is reversed, and when the

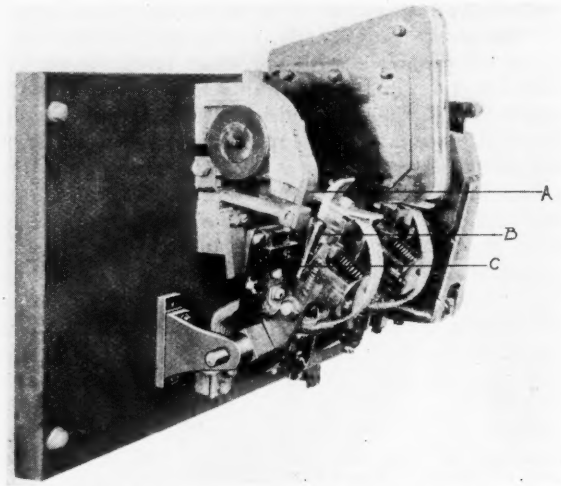



FIG. 1. 1000-AMP. CONTACTOR WITH ONE CHUTE REMOVED

main tips close, the blowout coil is cut out of the current, which saves heating of the coil from being on the line continually.

The main tips are self alining on the moving element, and are made of drop forged copper, being permanently attached to flexible leads which are screwed

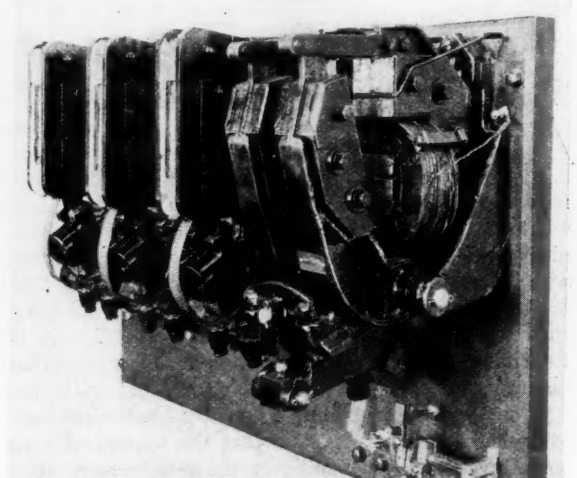


FIG. 2. 2000-AMP. CONTACTOR

on the terminal studs. The arcing tips are provided with long horns which help to prevent the concentration of the arc at one point and aid in its rapid extinction by stretching it out. This combination of contact parts not only eliminates laminated brush contacts, but reduces the number of joints in the main circuit to two in number with a consequent decrease in local heating.

The arc chutes and blowout coils are also of improved design. The former are narrow and of much larger area, having dividing barriers giving a restricted type of chute that gives the arc greater velocity, and prevents local burning of the chutes and tips due to concentration of the arc at any point. The blowout coil has more turns in spite of the narrow arc chute, giving an exceedingly efficient blowout.

The 2000-amp. contactors have two operating magnets, each, similar to the magnet of the 1000-amp. size, but they are operated by a single coil. The two armatures are connected mechanically to the shaft by an equalizer, so they will pull together. The arc chutes and moving contact tips are interchangeable with those of the 1000-amp. size. Two contact studs are provided for each incoming and outgoing lead, so that smaller studs and terminals may be used, and the cables attached more conveniently.

The wearing contact parts on both sides are designed so their removal and replacement is a simple matter, involving the least possible delay. This becomes a highly important feature when it is realized what delays of only a few minutes, caused by machines held up for repairs, may cost the owner.

## How Is Your Generator Working?

IN THIS enlightened world of ours, everybody wants to be a live-wire. Business in the daytime and recreation in the evening demand much energy.

The human body is a generator which can produce just so much voltage, or energy. If our circuit is overloaded, we may blow out a fuse. If our circuit is not inspected at intervals, there is danger of short circuits, which danger sometimes leads not only to the blowing out of a fuse but, if treatment is neglected, to the burning out of the dynamo.

Systems, electrical as well as physical, need a certain amount of insulation. The insulation of the physical system is maintained by a tissue of fat. The wires become exposed when a person grows too thin. A man who operates on high-tension current needs plenty of insulation, otherwise fat. Too much insulation, however, is wasted.

In short, it is necessary to keep our generators well fed with power and regularly watched over and tested by expert electricians. It is necessary to keep our bodies well nourished with healthy food and fresh air. They need to be regularly watched over and tested through periodical examinations by expert physicians.

By thus watching over and guarding the human body, a power of resistance can be built up which will protect against the most insidious of all diseases, tuberculosis.

Men and women must feel an individual responsibility in helping to decrease the spread of this destructive disease. Mothers and fathers must watch out for the health habits in the home. From childhood, persons should be taught the four practical ways to keep the body in such a healthy physical state that it will have the power to resist tubercle bacilli. These are: (1) Good, nourishing food; (2) Plenty of sleep with plenty of fresh outdoor air; (3) Plenty of exercise out-of-doors; and (4) Periodic physical examinations by an expert physician.

The tragedy of tuberculosis is that its onslaught usually comes as suddenly as an electric shock. It springs into existence in families of the rich, the poor, the weak, the strong. Since nearly everyone is infected during childhood and since in a weakened system the disease may all at once develop, there is no more warning oftentimes than there is when a fuse unexpectedly burns out.

Education of the public in the ways to prevent tuberculosis by maintaining a high standard of health is carried on throughout the country by the National Tuberculosis Association and its 1200 affiliated organizations. In the 15 yr. since the association began its efforts, the death rate from tuberculosis in this country has fallen from 200 per every 100,000 of population to 120 per 100,000 of population and funds to carry on this work are secured from the sale of Tuberculosis

Christmas Seals and the 14th annual Christmas Seal Sale will be held in December of this year. Every dollar you invest in Christmas Seals helps in the educational campaign to stamp out tuberculosis.

## News Notes

ANNOUNCEMENT is made of the consolidation of the Richardson-Phenix Co. and the S. F. Bowser Co., of Ft. Wayne, Ind. Assets of the consolidated companies are valued at $10,000,000. Headquarters will be located at the office of the S. F. Bowser Co., the personnel of both companies being retained.

During the life of these companies—36 yr. for the Bowser Co. and 20 yr. for the Richardson-Phenix—lubrication has grown from a haphazard affair to careful scientific study of needs and engineering plans to meet those needs, as well as to conserve lubricants and reclaim them for further use.

S. F. Bowser and J. Wm. Peterson will remain as presidents of the constituent companies, S. B. Bechtel, vice-president of the S. F. Bowser Co., becoming vice-president and general manager of the Richardson-Phenix Co., and Mr. Peterson being also vice-president of the Bowser Co. The Milwaukee shops will be continued in operation.

KIELEY & MUELLER, INC., of New York, has appointed the following additional western representatives and distributors: Reeves & Skinner Machinery Co., at St. Louis, Mo.; Kent Engineering Co., at Omaha, Neb.; A. C. Price, at Minneapolis, Minn.

EDWARD M. ELIOT has been appointed assistant to the vice-president of the Underfeed Stoker Co. of

America, having resigned as service manager for the Diamond Power Specialty Co., of Detroit. Mr. Eliot was engaged in power plant design and construction for 8 yr. with the Oregon Electric Railway Co., The Electric Bond & Share Co., and others. For the past 7 yr. he has specialized in the organization of service work and repair sales.

METALS COATING CO. of America is now in full operation at its new plant, 495-497 North 3d St., Philadelphia, having removed from the former Boston, Mass., and Woonsocket, R. I., locations.

THE EXETER MACHINE WORKS, INC., of West Pittston, Pa., announces the appointment of W. P. MacKenzie Co. as sales agent in the Phliadelphia and Baltimore districts; also, of The English Tool & Supply Co. as sales agent in the Kansas City district.

THE WESTINGHOUSE Electrical & Manufacturing Co. announces the purchase of the manufacturing building of the Kilbourne & Clarke Manufacturing Co. in Seattle, Wash., for a consideration of $130,000. Acquirement of this property will provide facilities for assembling and testing electrical machinery, the manufacture of switchboards and panels, warehousing of its products and the housing of its sales organization.

IN THE article describing the Kelley's Falls plant of the Manchester Traction, Light and Power Co., of Manchester, N. H., in our issue of Nov. 15, the name of the manufacturer of the coal handling equipment was omitted through an oversight. This equipment was furnished by the Stephens-Adamson Mfg. Co., of Aurora, Ill.

## Catalog Notes

TESTING and packing of gage glasses are discussed in a pamphlet sent out by H. A. Rogers Co., New York, and relating particularly to Moncrieff's gage glasses.

TYPE LC crane safety switches are illustrated on a small blotter (No. 57) for vest pockets, which is being distributed by the Westinghouse Electric & Manufacturing Co.

REDUCING VALVES, pump governors, pressure regulators, hot water tank regulators, control valves and damper regulators are described and illustrated in Junior Catalog No. 21, just published by the Atlas Valve Co., Newark, N. J.

CURTIS ENGINEERING Specialties is the title of a new and attractive catalog issued by Julian d'Este Co., of Boston, Mass. It covers pressure and temperature regulators for steam and water, damper regulators, taps and relief valves. Construction and action of each is described with a list of sizes, capacities and prices.

LATEST DESCRIPTION of the new chain screen doors for furnaces and ovens, for keeping the heat in and the cold out of metallurgical glass, chemical and boiler furnaces, is contained in a pamphlet from E. J. Codd Co., Baltimore, Md.

THE HANDY wiring tables and illumination data just issued by the Geo. Cutter Works of the Westinghouse Electric & Mfg. Co. at South Bend, Ind., contains a considerable amount of data which is of interest to anyone connected with the problems of wiring and lighting offices, factories, etc. Tables of foot candle intensities recommended for different classes of service, are included in this booklet, and an interesting discussion of lighting installations is made. Several new devices manufactured by the company are shown in this booklet.

GILLIS & GEOGHEGAN, of New York City, have just issued a 20-page 8½ by 11-in., two-color catalog. It is fully illustrated with photographs of actual installations of G. & G. telescopic hoists, as used for handling ash cans, barrels, trays and other loads.

"DON'T LET IT HAPPEN TO YOU" is the title of a booklet written and illustrated particularly for those operating or owning power pipe threading machines. The booklet contains useful data and information regarding the care and use of dies for threading pipe. The publisher, Williams Tool Corporation, Erie, Pa., will be glad to mail copies on request to those interested.

"OIL ENGINES" and "Stationary Steam Engines" are the titles of two attractively illustrated booklets just published by the Vacuum Oil Co. The booklets are two of many pieces of educational literature which the Vacuum Oil Co. publishes on machinery, its construction, operation and lubrication. The first named booklet is devoted to the treatment of the surface ignition type of oil engine and takes up in detail its field of service, principle of operation, its construction, operating instructions in regard to cooling, methods of lubrication and kinds of oil required. The booklet is handsomely illustrated with numerous colored diagrams and contains valuable data in regard to lubrication.

"Stationary Steam Engines" is divided into two parts, the first part taking up the classification, factors of operation principles, lubrication, etc., of reciprocating steam engines while part two concerns itself with the boiler plant and steam production.

BULLETIN 46,041, issued by the General Electric Co., fully describes the Type H-2 A-C temperature indicator, developed to safeguard transformer units from deterioration due to overheating. This instrument affords the operator an easy and convenient means of determining at the switchboard the hot spot temperature of the windings of transformers under all operating conditions.

With the present method of rating transformers, namely, for continuous operation at 55 deg. C. rise, it is important to know the actual temperature of the windings under load because the guaranteed temperature is so much closer to the maximum safe temperature that a few degrees variation from the allowable rise may have considerable effect on the life of the transformer. It is evident that the determination of the internal temperature not only protects against overheating, but, under certain conditions, may with safety permit of greater output. This is not only true for short-time overloads, but is also true for protracted overloads when the ambient temperature is below that specified in the A. I. E. E. Standardization Rules.

The bulletin contains a complete wiring diagram, as well as the principles of operation, safety and accuracy of this temperature indicator.